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PHYSICO-THEOLOGY:

OR,

A DEMONSTRATION

OF THE

BEING AND ATTRIBUTES OF GOD,

FROM

HIS WORKS OF CREATION.

BEING THE

Substance of Sixteen Discourses delivered in St. Mary-le-Bow
Church, London, at the Hon. Mr. BOYLE's Lectures,
in the Years 1711 and 1712.

By the Rev. W. DERHAM,

CANON OF WINDSOR, RECTOR OF UPMINSTER IN ESSEX,
AND F. R. S.

A NEW EDITION;

With additional Notes; a Translation of the Latin and Greek
Quotations; and a Life of the Author.

IN TWO VOLUMES.

ILLUSTRATED WITH PLATES.

Mala & impia consuetudo est contra Deos disputare, siue animo id fit, siue simulatè.

—“ It is a wicked and impious custom to dispute against the existence
and attributes of God, whether it be done in earnest, or only through
affectation.”

Cic. de Nat. Deor. l. 2. fine.

VOL. II.

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BOOK IV.

Of Animals in general.

CHAP. XI.

Of the Food of Animals.

THE preceding reflection of the *Psalmist*, mindeth me of another thing in common to animals, that pertinently falleth next under consideration, which is, the *appointment of food*, mentioned in *verse 27, 28*, of the last cited *Psalm*, *civ.* *These* [creatures] *wait all upon thee, that thou mayest give them their meat in due season. That thou givest them, they gather; thou openest thy hand, they are filled with good.* The same is again asserted in *Psal. cxlv. 15, 16.* *The eyes of all wait upon thee, and thou givest them their meat in due season. Thou openest thy hand, and satisfieth the desire of every living thing.*

What the *Psalmist* here asserts, affords us a glorious scene of the Divine providence and management. Which, (as I have shewed it to concern itself in other lesser things,) so we may presume, doth it exert itself particularly in so grand an affair as that of food, whereby the animal world subsists: And this will be manifested, and the *Psalmist's* observations

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servations exemplified, from these six following particulars.

I. From the subsisting and maintaining such a large number of animals, throughout all parts of the world.

II. From the proportionate quantity of food to the consumers.

III. From the variety of food suited to the variety of animals: or, the delight which various animals have in different food.

IV. From the peculiar food which peculiar places afford to the creatures suited to those places.

V. From the admirable and curious apparatus made for the gathering, preparing, and digestion of the food. And,

VI. *and lastly*. From the great sagacity of all animals, in finding out and providing their food.

I. It is a great act of the Divine power and wisdom, as well as goodness, to provide food for such a world of animals (*a*) as every where possess the terraqueous globe; on the dry land; and in the sea and waters; in the torrid and frozen zones,

(*a*) *Pasunt animantibus largè & copiosè Natura eum, qui cuique aptus erat, comparavit.*—"Nature hath abundantly furnished to all animals that food which is most proper for them."—*Cic. de Nat. Deor.* l. 2. c. 47.

Ille Deus est,—qui per totum orbem armenta dimisit, qui gregibus ubique passim vagantibus pabulum præstat.—"He who hath covered the earth with living creatures, He who supplies each animal with its proper food, He is GOD."—*Senec. de Benef.* l. 4. c. 6.

as well as the temperate. That the temperate climates, or at least the fertile valleys, and rich and plentiful regions of the earth, should afford subsistence to many animals, may appear less wonderful perhaps: but that in all other the most likely places for supplies, sufficient food should be afforded to such a prodigious number, and so great variety of beasts, birds, fishes, and insects, is owing to that Being, who hath as wisely adapted their bodies to their place and food, as carefully provided food for their subsistence there.

But I shall leave this consideration, because it will be illustrated under the following points; and proceed,

II. To consider the adjustment of the quantity of food, in proportion to the consumers. In all places there is generally enough; nay, such a sufficiency, as may be styled a plenty; but not such a superfluity, as to waste and corrupt, and thereby annoy the world. But that which is particularly remarkable here, is, that among the great variety of foods, the most useful is the most plentiful, most universal, easiest propagated, and most patient of weather, and other injuries. As the herbaceous eaters (for instance) are many, and devour much; so the dry-land surface we find every where almost naturally carpeted over with grass, and other agreeable wholesome plants; propagating themselves in a manner every where, and scarcely destroyable by the weather, the plough, or any art. So likewise for
B 2 grain,

grain, especially such as is most useful, how easily is it cultivated, and what a large increase doth it produce? *Pliny's* example of wheat (*b*), is a sufficient instance in this matter; which (as that curious heathen observes) being principally useful to the support of man, is easily propagated, and in great plenty: and an happy faculty that is of it, that it can bear either extremes of heat or cold, so as scarce to refuse any clime.

III. Another wise provision the Creator hath made relating to the food of animals, is, that various animals delight in various food (*c*); some in grass and herbs; some in grain and feeds; some in flesh; some in insects; some in this (*d*), some in that; some

(*b*) *Tritico nihil est fertilius: hoc ei Natura tribuit, quoniam eo maximè alit hominem; utpote cùm è modio, si sit aptum solum—150 modii reddantur. Misit D. Augusto procurator—ex uno grano (vix credibile dictu) 400 paucis minùs germina. Misit & Neroni similiter 340 stipulas ex uno grano.*—“Nature has given a most wonderful fertility to wheat; because it is the grain which is most essential for the nourishment of man.—A single bushel of good wheat will give a return of 150. One of the Roman procurators sent to Augustus 400 ears produced from one grain (a thing scarcely credible). So likewise 340 were sent to Nero produced from one grain.”—*Plin. Nat. Hist.* l. 18. c. 10.

(*c*) *Sed illa quanta benignitas Naturæ, quòd tam multa ad vescendum, tam varia, tam jucunda gignit; neque ea uno tempore anni, ut semper & novitate delectemur & copiâ.*—“How great is the bounty of Nature in producing food so various, so delectable; and that too not at one season, but in succession, thus giving at once abundance and variety.”—*Cic. de Nat. Deor.* l. 2. c. 53.

(*d*) *Swammerdam* observes of the *Ephemeron* worms, that their food is clay, and that they make their cells of the same. Upon which

some more delicate and nice; some voracious and catching at any thing. If all delighted in, or subsisted only upon one sort of food, there would not be sufficient for all; but every variety choosing various food, and perhaps abhorring that which others like, is a great and wise means that every kind hath enough, and oftentimes somewhat to spare*.

It deserves to be reckoned as an act of the Divine appointment, that what is wholesome food to one, is nauseous, and as a poison to another; what is a sweet and delicate smell and taste to one, is foetid and loathsome to another: by which means all the provisions the globe affords are well disposed of. Not only every creature is well provided for, but a due consumption is made of those things that otherwise would encumber the world,

which occasion he saith of *moths*, that eat wool and fur, *There are two things very considerable: 1. That the cells they make to themselves, wherein they live, and with which (as their house, tortoise-like) they move from place to place, they make of the matter next at hand. 2. That they feed also on the same; therefore when you find their cells, or rather coats or cases to be made of yellow, green, blue, or black cloth, you will also find their dung of the same colour.* Swam. Ephem. vita, published by Dr. Tyson, chap. 3.

* That most accurate observer of Nature, Linnæus, has remarked that the cow eats 276 species of plants, and rejects 218; the goat eats 449, and rejects 126; the sheep eats 387, and rejects 141; the horse eats 262, and rejects 212; but the hog, more nice in its taste than any of the former, eats but 72 plants, and rejects all the rest.

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lie in the way, corrupt, rot, stink and annoy, instead of cherishing and refreshing it. For our most useful plants, grain, and fruits, would mould and rot; those beasts, fowls, and fishes, which are reckoned among the greatest dainties, would turn to carrion, and poison us: nay, those animals which are become carrion, and many other things that are noisome, both on the dry land and in the waters, would be great annoyances, and breed diseases, was it not for the provision which the infinite Orderer of the world hath made, by causing these things to be sweet, pleasant, and wholesome food to some creature or other, in the place where those things fall: to dogs, ravens, and other voracious animals, for instance, on the earth; and to rapacious fishes, and other creatures inhabiting the waters.

Thus is the world, in some measure, kept sweet and clean, and at the same time, divers species of animals supplied with convenient food. Which providence of God, particularly in the supplies afforded the *ravens*, is divers times taken notice of in the Scriptures (*e*); but whether for the reasons now hinted, or any other special reasons, I shall not enquire. Thus our Saviour, *Luke xii. 24. Consider the ravens; for they neither sow nor reap, which neither have storehouse nor barn, and God feedeth them.* It is a manifest argument of the Divine care and providence, in supplying the world with

(*e*) *Job xxxviii. 41. Psal. cxlvii. 9.*

food and necessaries, that the *ravens*, accounted as unclean, and little regarded by man, destitute of stores, and that live by accidents, by what falleth here and there; that such a bird, I say, should be provided with sufficient food; especially if that be true which *Aristotle* (*f*), *Pliny* (*g*), and *Ælian* (*h*), report of their unnatural affection and cruelty to their young: “That they expel them their nests
“ as soon as they can fly, and then drive them out
“ of the country.”

Thus having considered the wise appointment of the Creator, in suiting the variety of food to variety of animals: let us in the

IVth Place, Take a view of the peculiar food, which particular places afford to the creatures inhabiting therein.

It hath been already observed (*i*), That every place on the surface of the terraqueous globe, is stocked with proper animals, whose organs of life and action are curiously adapted to each respective place. Now it is an admirable act of the Divine providence, that every place affords a proper food

(*f*) *Aristot.* l. 9. c. 31. *Hist. Animal.*

(*g*) *Pliny* affirms this of the *crow* as well as *raven*: *cætæræ omnes* [i. e. *cornices*] *ex eodem genere pellunt nidis pullos, ac volare cogunt, sicut ♂ corvi, qui—robustos suos fetus fugant longius.*—
“ All the species of ravens, crows, rooks, &c. drive the young from the nest, and force them to use their wings, as soon as they become strong.”—*Nat. Hist.* l. 10. c. 12.

(*h*) *Var. Hist.*

(*i*) *Chap.* ix.

to all the living creatures therein. All the various regions of the world, the different climates (*k*), the various soils, the seas, the waters, nay our very putrefactions, and most nasty places about the globe, as they are inhabited by some or other animal, so they produce some proper food or other, affording a comfortable subsistence to the creatures living there. I might for instances (*l*) of this bring the great

(*k*) *Admiranda Naturæ dispensatio est, ut aliter, alioque modo, tempore, & industriâ colatur terra septentrionalis, aliter Æthiopia, &c. Quoad Aquilonares, hoc cœrum est, in plerisque agris Vestrogothorum, parte objectâ meridionali plagæ, hordeum spatio 36 dierum à semine projecto maturum colligi, hoc est, à fine Junii usque medium Augusti, aliquando celerius. Ea namque maturitas ex soli naturâ, aërisque clementiâ, ac humore lapillorum fovente radices, soleque torrente, necessario provenit, ut ita nascatur, ac maturetur, talesque spicæ sex ordines in numero aristæ habent.*—"The economy of Nature is wonderful in the various distribution of seasons and soils in the opposite quarters of the world, &c. In the northern parts, for instance in West Gothland, in those places that have a south exposure, barley ripens in 36 days from the time of sowing; that is between the end of June and the middle of August, and sometimes sooner. This earliness proceeds from the nature of the soil, the mildness of the air, the moisture which the small stones retain about the roots of the plants and the great heat of the sun. In this species of barley each ear has six rows of grains."—*Ol. Mag. Hist.* l. 15. c. 8. *Prata & pascua tantâ luxuriant graminum ubertate ac diversitate, ut necessum sit inde arcere jumenta, nè nimio herbarum esu crepent, &c.*—"The meadows and pastures abound in such a variety of grapes, and those so luxuriant that it is necessary to remove cattle from them, when fed, for fear of their bursting."—*Id.* *ib.* l. 19, c. 36.

(*l*) Among the many noble contrivances for food, I cannot but attribute that universal aliment, *bread*, to the revelation,

great variety of herbs, fruits, and grains on the earth, the large swarms of insects in the air, with every other food of the creatures residing in the earth, or flying in the air. But I shall stop at the *waters*, because the *Psalmist*, in the fore-cited civth *Psal.*, speaks with relation to the especial provision for the inhabitants of the waters; and also by reason that many land animals have their chief maintenance from thence.

Now one would think, that the waters were a very unlikely element to produce food for so great a number of creatures as have their subsistence from thence. But yet how rich a promptuary is it, not only to large multitudes of fishes, but also to many amphibious quadrupeds, insects, reptiles, and birds! From the largest *leviathan*, which the *Psalmist* saith (*m*) *playeth in the seas*, to the smallest mite in the lakes and ponds, all are plentifully pro-

lation, or at least the inspiration of the Creator and Conservator of mankind; not only because it is a food used in all or most parts of the world; but especially because it is of incomparable use in the great work of digestion, greatly assisting the ferment, or whatever causes the digestion of the stomach. Of which take this example from the noble Mr. Boyle. "He extracted a *menstruum* from bread alone, that would work on bodies more compact than many hard minerals, nay even on glass itself, and do many things that *aqua-fortis* could not do.—Yet by no means was this so corrosive a liquor as *aqua fortis* or as the other *acid menstruum*." Vide the ingenious and learned Dr. Harris's *Lex. Tech.* verbo *Menstruum*, where the way of preparing it may be met with. See *postea*, book x. addition to note (*r*).

(*m*) *Psal.* civ. 26.

vided

vided for ; as is manifest from the fatness of their bodies, and the gaiety of their aspect and actions.

And the provision which the Creator hath made for this service in the waters is very observable ; not only by the germination of divers aquatic plants there, but particularly by appointing the waters to be the matrix of many animals, particularly of many of the insect-kind, not only of such as are peculiar to the waters, but also of many appertaining to the air and the land, who, by their near alliance to the waters, delight to be about them, and by that means become a prey, and plentiful food to the inhabitants of the waters. And besides these, what prodigious shoals do we find of minute animals, even sometimes discolouring the waters (*n*) ! Of these (not only in the

(*n*) The insects that for the most part discolour the waters, are the small insects of the *shrimp-kind*, called by *Swammerdam*, *pulex aquaticus arborefcens*. These I have often seen so numerous in stagnating waters in the summer months, that they have changed the colour of the waters to a pale or deep red, sometimes a yellow, according to the colour they were of. Of this *Swammerdam* hath a pretty story told him by Dr. *Florence Schuyt*, viz. *Se aliquando studiis intentum, magno quodam & horrifico rumore fuisse turbatum, & simul ad causam ejus inquirendam excitatum ; verum se vix eum in finem surrexisse, cum ancilla ejus pene exanimis adcurreret, & multo cum singultu referret, omnem Lugduni [Batavorum] aquam esse mutata in sanguinem.*—"One day, when intent upon his studies, he was disturbed by a violent noise and uproar ; and rising to inquire the cause, a servant maid ran up to him, half dead with fright, and in great agitation informed him that all the water in *Leyden* was turned into blood."

the water, but in the air and on land) I have always thought there was some more than ordinary use intended by the all-wise Creator. And having bent many of my observations that way, I have evidently found it accordingly to be. For be they never so numberless or minute, those animals serve for food to some creatures or other. Even those animalcules in the waters, discoverable only with good microscopes, are a repast to others there, as I have often with no less admiration than pleasure seen (o).

But

blood."—The cause of which, upon examination he found to be only from the numerous swarms of those *pulices*. Vide *Swamm. Hist. Insect.* p. 70.

The cause of this great concourse and appearance of those little insects, I have frequently observed to be to perform their coit; which is commonly about the latter end of *May* and in *June*. At that time they are very venereous, frisking, and catching at one another; and many of them conjoined tail to tail, with their bellies inclined one towards another.

At this time also they change their skin or *slough*; which I conceive their rubbing against one another mightily promoteth. And what if at this time they change their quarters? Vide *book viii. chap. 4. note (f)*.

These small insects, as they are very numerous, so are food to many water-animals. I have seen not only *ducks* shovel them up as they swim along the waters, but divers insects also devour them, particularly some of the middle-sized *squilla aquatica*, which are very voracious insects.

(o) Besides the *pulices* last mentioned, there are in the waters other animalcules very numerous, which are scarce visible without a microscope. In *May*, and the summer months, the green scum on the top of stagnating waters, is nothing else but prodigious numbers of these animalcules: so is likewise the green

But now the usual objection is, that necessity maketh use (*p*). Animals must be fed, and they make

green colour in them, when all the water seems green. Which animalcules, in all probability, serve for food to the *pulices aquatici*, and other the minuter animals of the waters. Of which I gave a pregnant instance in one of the *nymphæ* of gnats, to my friend the late admirable Mr. Ray, which he was pleased to publish in the last edition of his *Wisdom of God in the Creation*, p. 430.

(*p*) *Nil adeò quoniam natum' est in corpore, ututi Possemus, sed quòd natum' est, id procreat usum.*

“That man to selfish use turns Nature's store Proves not design in her, but his rapacious power.”

And afterwards,
*Propterea capitur cibis, ut suffulciat artus,
Et recreet vireis interdatus, atque patentem
Per membra ac penas ut amorem obturet edendi.*

“When faint with hunger, with fatigues oppress'd,
Instinct impels us to the nutrient feast.”

And after the same manner he discourseth of thirst, and divers other things. Vide *Lucret.* l. 4. v. 831. &c.

Against this opinion of the *Epicureans*, *Galen* ingeniously argues in his discourse about the hand. *Non enim manus ipsæ* (saith he) *hominem artes docuerunt, sed ratio. Manus autem ipsæ sunt artium organa; sicut lyra musici.*—*Lyra musicam non docuit, sed est ipse artifex per eam, quâ præditus est, rationem: agere autem non potest ex arte absque organis, ita & una qualibet anima facultates quasdam à suâ ipsius substantiâ obtinet.*—*Quòd autem corporis particule animam non impellunt,*—manifestè videre licet, si animalia recens nata consideres, quæ quidem priùs agere conantur, quàm perfectas habeant particulas. Ego namque bovis vitulum cornibus petere conantem sæpenumero vidi, antequam ei nata essent cornua; et pulum equi calcitrantem, &c. Omne enim animal suæ ipsius animæ facultates, ac in quos usus partes suæ polleant maximè, nullo doctore, præsentit.—Quâ igitur ratione dici potest, animalia partium usus à

make use of what they find : in the desolate regions, and in the waters, for instance, they feed upon what

partibus doceri, cum & antequàm illas habeant, hos cognoscere videntur? Si igitur ova tria acceperis, unum aquile, alterum anatis, reliquum serpentis, & calore modico foveris, animaliaquè excluseris; illa quidem alis volare conantia, antequàm volare possint; hoc autem revolvi videbis, & serpere affectans, quamvis molle adhuc & invalidum fuerit. Et si, dum perfectæ erunt, in unâ eâdemque domo nutritiveris, deinde ad locum subdialem ducta emiseris, aquila quidem ad sublime; anas autem in paludem;—serpens verò sub terrâ irrepet—Animalia quidem mihi videntur Naturâ magis quàm ratione artem aliquam [τεχνην artificiosam] exercere: apes fingere alveolos, &c.

“Man does not derive his skill in arts from having hands, but from being endowed with reason. The hands are nothing more than the instruments of arts as the lyre is of music. The lyre does not teach us music.—It is reason that teaches us through its means.—But reason cannot act in an artificial manner without organs.—Thus each soul derives certain faculties from its own substance.—But that the soul is not impelled by the particles of the body, is evident from this, that an animal newly born endeavours to act before its particles are perfectly formed. I have oftentimes seen a calf attempt to butt with its head, before its horns were sprung; and in like manner a foal striking with its hoofs. All animals untaught make use of those powers which Nature has given them: nor can it be said, that the organs themselves prompt to their several uses, if those uses manifest themselves before the organs are developed. Take three different eggs, one of an eagle, another of a duck, and a third of a serpent, and hatch them by a moderate heat. The two former young will be observed attempting to fly before their wings are completely formed; the latter will make aukward attempts to coil itself up and to creep. And if the young animals are kept in the same place till their form is perfected, and then set at liberty, the eagle will immediately soar aloft into the air, the duck will betake itself to the pool, and the serpent will burrow under ground. The artificial operations of animals

what they can come at; but, when in greater plenty, they pick and chuse.

But this objection hath been already in some measure answered by what hath been said; which plainly argues design, and a super-intending wisdom, power, and providence in this special business of food. Particularly the different delight of divers animals in different food, so that what is nauseous to one, should be dainties to another, is a manifest argument, that the allotment of food is not a matter of mere chance, but entailed to the very constitution and nature of animals; that they chuse this, and refuse that, not by accident, or necessity, but because the one is a proper food, agreeable to their constitution, and so appointed by the infinite contriver of their bodies; and the other is disagreeable and injurious to them.

But all this objection will be found frivolous, and the wisdom and design of the great Creator will demonstratively appear, if we take a survey,

V. Of the admirable and curious apparatus in all animals, made for the gathering, preparing, and digestion of their food. From the very first entrance, to the utmost exit of the food, we find every thing contrived, made and disposed with the utmost dexterity and art, and curiously adapted to the place the animal liveth in, and the food it is to be nourished with.

animals seem to me to proceed rather from Nature, than from any reasoning power; as the bees form cells, &c."—*Galen de Usu Part. c. 3.*

Let

Let us begin with the *mouth*. And this we find, in every species of animals, nicely conformable to the use of such a part; neatly sized and shaped for the catching of prey, for the gathering or receiving food (*q*), for the formation of speech, and every other such like use (*r*). In some creatures it is wide and large, in some little and narrow; in some with a deep incisure up into the head (*s*), for the better catching and holding of prey,

(*q*) *Alia dentibus prædantur, alia unguibus, alia rostri aduncitate carpunt, alia latitudine [eiusdem] ruunt, alia acumine excavant, alia sugunt, alia lambunt, sorbent, mandunt, vorant. Nec minor varietas in pedum ministerio, ut rapiant, distrahant, teneant, premant, pendeant, tellurem scabere non cessent.*—"Some prey with their teeth, others with claws; some scrape with a crooked beak, others strike with a broad one; some suck, others lick, sip, eat, swallow. Nor is there less variety in the use of their feet, in snatching, tearing, grasping, pressing, hanging by, and scraping the ground."—*Plin. Nat. Hist.* l. 10. c. 71.

(*r*) Because it would be tedious to reckon up the bones, glands, muscles, and other parts belonging to the mouth, it shall suffice to observe, that, for the various services of man's mouth, besides the muscles in common with other parts, there are five pair, and one single one proper to the lips only, as Dr. *Gibson* reckons them: but my most diligent and curious friend the late Mr. *Cowper*, discovered a sixth pair. And accordingly Dr. *Drake* reckons six pair, and one single one proper to the lips, l. 3. c. 13.

(*s*) *Galen* deserves to be here consulted, who excellently argues against the casual concurrence of the atoms of *Epicurus* and *Asclepiades*, from the provident and wise formation of the mouths of animals, and their teeth answerable thereto. In man, his mouth without a deep incisure, with only one canine tooth on a side, and flat nails, because, saith he, *Hic Natura certo*

prey, and more easy comminution of hard, large, and troublesome food; in others with a much shorter incisure, for the gathering and holding of herbaceous food.

In *insects* it is very notable. In some forcipated, to catch, hold, and tear their prey (*t*). In some aculeated, to pierce and wound animals (*u*), and suck

certò sciebat, se animal mansuetum ac civile effingere, cui robur & vires essent ex sapientiâ, non ex corporis fortitudine.—"For Nature in the formation of man, knew that she was framing a mild and civilized animal, who derived his strength and powers from his understanding, and not from hardness of bodily conformation." But for *lions*, *wolves*, and *dogs*, and all such as are called *καρχαρόδοντες*, (or having sharp, ferrated teeth,) their mouths are large, and deep cut; teeth strong and sharp, and their nails sharp, large, strong, and round, accommodated to holding and tearing. Vide *Galen de Uf. Part. l. 11. c. 9.*

(*t*) Among insects, the *squilla aquatica*, as they are very rapacious, so are accordingly provided for it; particularly the *squilla aquatica maxima recurva* (as I call it), who hath somewhat terrible in its very aspect, and in its posture in the water, especially its mouth, which is armed with long, sharp hooks, with which it boldly and greedily catcheth any thing in the waters, even one's fingers. When they have seized their prey, they will so tenaciously hold it with their forcipated mouth, that they will not part therewith, even when they are taken out of the waters, and jumbled about in one's hand. I have admired at their peculiar way of taking in their food; which is done by piercing their prey with their *forcipes* (which are hollow) and sucking the juice thereof through them.

The *squilla* here mentioned is the first and second in *Mouffet's Theat. Insect. l. 2. c. 37.*

(*u*) For instance of insects endued with a spear, I shall, for its peculiarity, pitch upon one of the smallest, if not the very smallest of all the gnat-kind, which I call, *culex minimus nigricans*.

such their blood. And in others strongly rigged with jaws and teeth, to gnaw and scrape out their food,

cans maculatus sanguisuga. Among us in *Essex*, they are called *nidiots*; by *Mouffet*, *midges*. It is about one tenth of an inch, or somewhat more, long, with short *antennæ*, plain in the female, in the male feathered, somewhat like a bottle-brush. It is spotted with blackish spots, especially on the wings, which extend a little beyond the body. It comes from a little slender eel-like worm, of a dirty white colour, swimming in stagnating waters by a wrigling motion; as in *fig. 7*, Plate E.

Its *aurelia* is small, with a black head, little short horns, a spotted, slender, rough belly. Vide *fig. 8*. It lies quietly on the top of the water, now and then gently wagging itself this way and that.

These *gnats* are greedy blood-suckers, and very troublesome where numerous; as they are in some places near the *Thames*, particularly in the breach-waters that have lately befallen near us in the parish of *Dagenham*; where I found them so vexatious, that I was glad to get out of those marshes. Yea, I have seen horses so stung with them, that they have had drops of blood all over their bodies, where they were wounded by them *.

I have

* The animal here described is so extremely minute, that we can hardly suppose it to be endowed with any instrument so powerful as to pierce the skin of a horse. The *tabanus*, or gad fly, which sucks the blood of horses and oxen, has an apparatus for this purpose so extremely curious as to merit in this place a particular description; which we shall give by reference to the figure annexed; see Plate E, *fig. 1*. The whole apparatus is contained in a fleshy case not expressed in the figure. The feelers *aa* are of a spongy texture, and grey colour, covered with short hairs. They are united to the head by a small joint of the same substance. They defend the

food, to carry burdens (*w*), to perforate the earth, yea the hardest wood, yea even stones themselves, for houses (*x*) to themselves, and nests for their young.

I have given a figure (in *fig. 9.*) and more particular description of the *gnats*, because, although it be common, it is no where taken notice of by any author I know, except *Mouffet*, who, I suppose, means these *gnats*, which he calls *midges*; *c. 13. p. 82.*

(*w*) *Hornets* and *wasps* have strong jaws, toothed, where-with they can dig into fruits, for their food; as, also gnaw and scrape wood, whole mouthfuls of which they carry away to make their combs. *Vide infr. chap. 13. note (c).*

(*x*) *Monfieur de la Voye* tells of an ancient wall of free-stone in the *Benedictines Abbey* at *Caen* in *Normandy*, so eaten with worms, that one may run one's hand into most of the cavities; that these worms are small and black, lodging in a greyish shell; that they have large flattish heads, a large mouth, with four black jaws, &c. *Phil. Trans. No. 18.*

the other parts of the apparatus, being laid upon it side by side when the animal stings, and thus they preserve it from external injury. The wound is made by the two lancets *bb*, which are of a delicate structure but very sharp, formed like the dissecting knife of an anatomist, growing gradually thicker to the back. The two instruments *cc* appear as if intended to enlarge the wound by irritating the parts round it, for which they are jagged or toothed: they may also serve, from their hard and horny texture, to defend the tube *e*, which is of a softer nature and tubular to admit the blood, and convey it into the stomach. This tube is totally inclosed in a sort of sheath *f*, which entirely covers it. The above apparatus is considerably magnified by the microscope. Its natural size is represented by the small figure *g*.

EDITOR.

And

E

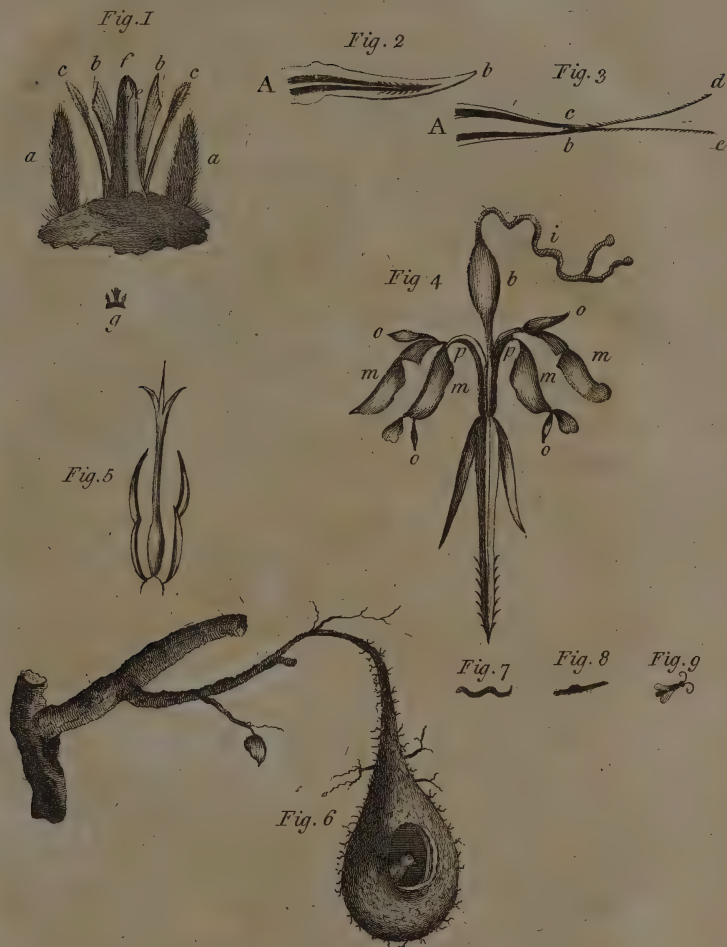


Fig. 1, The stinging & bloodsucking Apparatus of the *Tabanus*, or Gad-Fly. Fig. 2, 3, The Sting of a Bee sheathed and unsheathed. — Fig. 4 A more particular delineation of the Sting of a Bee, with its appendant Cartilages *m, m, m, m*, with the aid of which, & the four small muscles *o, o, o, o*, it moves the Sting different ways. *p, p*, Two muscles which draw the shanks of the Sting into its sheath. *b*, The poison-bag. *i*, the Tube that secretes the poison. Fig. 5, The Proboscis or Trunk of a Bee, wherewith they gather Honey, & take their nourishment. Fig. 6, the pendulous Tit-mouse of Lithuania. Fig. 7, 8, 9, the Gnat in its Worm, Aurelia, & Fly-state.

And lastly, in *birds* it is no less remarkable. In the first place, it is neatly shaped for piercing the air, and making way for the body through the airy regions. In the next place, it is hard and horny, which is a good supplement for the want of teeth, and causeth the bill to have the use and service of the hand. It's hooked form is of great use to the rapacious kind (*y*), in catching and holding their prey, and in the comminution thereof by tearing; to others it is no less serviceable to their climbing, as well as neat and nice comminution of their food (*z*). It's extraordinary length and slenderness is very useful to some, to search and grope for their food in moorish places (*aa*); as its length and breadth is to others to

(*y*) *Pro iis [labris] cornea & acuta volucribus rostra. Eadem raptis viventibus adunca: collectio, recta: herbas eruentibus limumque lata, ut suum generi. Jumentis vice manus ad colligenda pabula: ora apertiora laniatu viventibus.*—"The beaks of birds are horny and sharp. Those that live on the prey which they seize have crooked beaks; those whose food is already collected have straight beaks. Animals that feed on herbs, or on mud, have a broad snout, as the swine. The mouth serves in place of hands to cattle in collecting their food. The slaughtering and butchering tribes have very wide mouths."—*Plin. Nat. Hist. l. 11. c. 37.*

(*z*) *Parrots* have their bills nicely adapted to these services, being hooked, for climbing and reaching what they have occasion for; and the lower jaw being completely fitted to the hooks of the upper, they can as minutely break their food, as other animals do with their teeth.

(*aa*) Thus in *woodcocks*, *snipes*, &c. who hunt for worms in moorish ground, and, as Mr. *Willughby* saith, live also on the fatty unctuous humour they suck out of the earth. So also the bills of *curlews*, and many other sea-fowl, are very long,

to hunt and search in muddy places (*bb*): and the contrary form, namely, a thick, short, and sharp-edged bill, is as useful to other birds, who have occasion to husk and flay the grains they swallow. But it would be tedious, and endless, to reckon up all the various shapes, and commodious mechanism of all; the sharpness and strength of those who have occasion to perforate wood and shells (*cc*); the slenderness and neatness of such as pick up small insects; the cross-form of such as break up fruits (*dd*); the compressed form of others (*ee*), with many other curious and

long, to enable them to hunt for the worms, &c. in the sands on the sea-shore, which they frequent.

(*bb*) Ducks, geese, and divers others, have such long broad bills, to quaffer and hunt in water and mud; to which we may reckon the uncouth bill of the *spoon-bill*: but that which deserves particular observation in the birds named in these two last notes is, the nerves going to the end of their bills, enabling them to discover their food out of sight; of which see *book vii. chap. 2. note (e)*.

(*cc*) The *picus viridis*, or *green-woodspite*, and all the *wood-peckers*, have bills curiously made for digging wood, strong, hard, and sharp. A neat ridge runs along the top of the green *wood-pecker's* bill, as if an artist had designed it for strength and neatness.

(*dd*) The *loxia*, or *cross-bill*, whose bill is thick and strong, with the tips crossing one another; with great readiness breaks open fir-cones, apples, and other fruit, to come at their kernels, which are its food, as if the crossing of the bill was designed for this service.

(*ee*) The *sea-pie* hath a long, sharp, narrow bill, compressed side-ways, and every way so well adapted to the raising *limpets* from the rocks (which are its chief, if not only food,) that Nature (or rather the Author of Nature) seems to have framed it purely for that use.

artificial forms, all suited to the way of living, and peculiar occasions of the several species of birds. Thus much for the mouth.

Let us next take a short view of the *teeth* (*ff*), in which their peculiar hardness (*gg*) is remarkable, their growth (*hh*) also, their firm insertion and bandage in the gums and jaws, and their various shape and strength, suited to their various

(*ff*) *Those animals which have teeth on both jaws, have but one stomach; but most of those which have no upper teeth, or none at all, have three stomachs; as in beasts, the paunch, the read, and the feck; and in all granivorous birds, the crop, the echinus, and the gizzard. For as chewing is to an easy digestion, so is swallowing whole to that which is more laborious.* Dr. Grew's *Cosmol. Sacr. c. 5. sect. 24.*

(*gg*) *J. Peyer* saith, the teeth are made of convolved skins hardened; and if we view the grinders of deer, horses, sheep, &c. we shall find great reason to be of his mind. His observations are, *Mirum autem eos (i. e. dentes) cum primum è pelliculis imbricatis convolutis & mucò viscido constarent, in tantam dirigescere soliditatem, quæ ossa cuncta superet. Idem fit etiam in officulis ceraforum, &c.—Separatione factâ, per membranas conditur magna locellis, quos formant laminae tenues, ac duriusculæ ad dentis figuram antea divinitus compositaë.*—"It is wonderful that the teeth, which seem at first to consist of convolved pellicles and tough mucus, should afterwards acquire such a degree of solidity, as to surpass all manner of bones in hardness. The same thing is remarkable in cherry-stones," &c.—*J. Peyer Merycol. l. 2. c. 8.*

(*hh*) *Qui autem (i. e. dentes) renascuntur, minimè credendi sunt à facultate aliquâ plasticâ brutorum denuò formari, sed latentes tantummodo in conspectum producuntur augmento molis ex effluente succo.* "Those teeth which grow again, are not to be supposed formed by any plastic faculty in the animal, but lie concealed, and are gradually brought forward by deriving nourishment from the super-abundant juices."—*Id. ibid.*

occasion and use (ii); the foremost weak and farthest from the center, as being only preparers to the rest; the others being to grind and mince, are accordingly made stronger, and placed nearer the center of motion and strength. Likewise their various form (kk), in various animals is considerable, being all curiously adapted to the peculiar food (ll), and occasions of the several species of animals

(ii) From these, and other like considerations of the teeth, *Galen* infers, that they must needs be the work of some wise, provident *Being*, not *Chance*, nor a fortuitous concurrence of *atoms*. For the confirmation of which he puts the case, that suppose the order of the teeth should have been inverted, the *grinders* set in the room of the *incisors*, &c. (which might as well have been, had not the teeth been placed by a wise Agent) in this case, what use would the teeth have been of? What confusion by such a slight error in their disposal only? Upon which he argues, *At si quis choream hominum 32* (the number of the teeth) *ordine disposuit, eum ut hominem industrium laudaremus: cum verò dentium choream Natura tam bellè exornarit, nonne ipsam quoque laudabimus?*—"When we allow the ingenuity of any man who places 32 men in exact symmetrical order or in parallel lines, shall we not equally give the praise of ingenuity to Nature who has shewn the same symmetry in the arrangement of the teeth?"—and then he goes on with the argument, from the sockets of the teeth, and their nice fitting in them, which being no less accurately done, than what is done by a carpenter or stone-cutter in fitting a tenon into a mortice, doth as well infer the art and act of the wise *Maker* of animal bodies, as the other doth the act and art of man. And so he goes on with other arguments to the same effect. *Galen de Uf. Part. 1. II. c. 8.*

(kk) A curious account of this may be found in an *Extract of a Letter concerning the teeth of divers Animals*. Printed at *Paris*, in *M. Vaugnion's Complete Body of Chirurg. Oper. chap. 53.*

(ll) As it hath been taken notice of, that various animals delight in various food; so it constantly falls out, that their
teeth

animals (*mm*). And lastly, the temporary defect of them (*nn*), is no less observable in children, and such young creatures, where there is no occasion for them; but they would be rather an annoyance to the tender nipples and breasts.

teeth are accordingly fitted to their food; the rapacious, to catching, holding, and tearing their prey; the herbaceous, to gathering and comminution of vegetables: and such as have no teeth, as birds, their bill, claw, and gizzard are assisted with stones, to supply the defect of teeth. But the most considerable example of this kind is in some families of the insect-tribes, as the *papilio-kind*, &c. who have teeth, and are voracious, and live on tender vegetables in their *nympha*, or *caterpillar-state*, when they can only creep; but in their mature *papilio-state*, they have no teeth, but a *proboscis* or *trunk*, to suck up honey, (see Plate E, fig. 5.) &c. their parts for gathering food, as well as their food being changed, as soon as they have wings to enable them to fly to it.

(*mm*) It is remarkable in the teeth of fishes, that in some they are sharp, as also jointed, so as to fall back the better to catch and hold their prey, and to facilitate its passage into the stomach: so in others they are broad and flat, made to break the shells of snails and shell-fish devoured by them. These *teeth*, or *breakers*, are placed, in some, in the mouth; in some, in the throat; and in *lobsters*, &c. in the stomach itself; in the bottom of whose stomachs are three of those *grinders*, with peculiar muscles to move them.

(*nn*) What is there in the world can be called an act of providence and design, if this temporary defect of teeth be not such: that children, for instance, should have none whilst they are not able to use them, but to hurt themselves, or the mother; and that at the very age when they can take in more substantial food, and live without the breast, and begin to need teeth, for the sake of speech; that then, I say, their teeth should begin to appear, and gradually grow, as they more and more stand in need of them?

From the teeth, the grand instruments of mastication, let us proceed to the other ministerial parts. And here the *parotid*, *sublingual*, and *maxillary glands*, together with those of the cheeks and lips, are considerable; all lodged in the most convenient places about the mouth and throat, to afford that noble digestive salival liquor, to be mixed with the food in mastication, and to moisten and lubricate the passages, to give an easy descent to the food. The commodious form also of the jaws, deserves our notice: together with the strong articulation of the lowermost, and its motion. And lastly, the curious form, the great strength, the convenient lodgment and situation of the several muscles and tendons (oo), all ministering to this so necessary an act of life, as mastication is; they are such contrivances, such works, as plainly set forth the infinite Workman's care and skill.

(oo) It would be endless to particularize here, and therefore I shall refer to the anatomists; among the rest, particularly to *Galen*, for the sake of his descant upon this subject. For, having described the great accuracy of the contrivance and make of these parts, he saith, *Haud scio an hominum sit sobriorum ad fortunam opificem id revocare: aliqui quid tandem erit, quod cum providentiâ atque arte efficitur? omnino enim hoc ei contrarium esse debet, quod casu ac fortuito fit.*—"I cannot believe that it should ever enter into the conception of men in their sober senses, that all this contrivance should owe its origin to chance. If so, what is there which we can attribute to foresight and art? Most certainly the productions of the latter should be altogether contrary to those of the former."—*Galen. de Us. Part. l. 11. c. 7. ubi plura.*

Next

Next to the mouth, the *gullet* presenteth itself; in every creature well-sized to the food it hath occasion to swallow; in some but narrow, in others as large and extensive (*pp*); in all exceedingly remarkable for the curious mechanism of its muscles, and the artificial decussation and position of their fibres (*qq*).

And now we are arrived to the grand receptacle of the food, the *stomach*; for the most part as va-

(*pp*) The bore of the gullet is not in all creatures alike answerable to the body or stomach. As in the fox, which both feeds on bones, and swallows whole, or with little chewing; add next in a dog, and other offivorous quadrupeds, is is very large, viz. to prevent a contusion therein. Next in a horse, which though he feeds on grass, yet swallows much at once, and so requires a more open passage. But in a sheep, rabbit, or ox, which bite short, and swallow less at once, it is smaller. And in a squirrel, still lesser, both because he eats fine, and to keep him from disgorging his meat upon his descending leaps. And so in rats and mice, which often run along walls with their heads downwards. Dr. Grew's Comp. Anat. of Stom. and Guts, chap. 5.

(*qq*) Of this see Dr. Willis's Pharm. Rat. part. 1. sect. 1. c. 2. Steno also; and Peyer Mery, l. 2.

The description these give of the muscular part of the gullet, the late ingenious and learned Dr. Drake faith is very exact in ruminants, but not in men. In men, this coat (the second of the gullet) consists of two fleshy lamellæ, like two distinct muscles. The outward being composed of strait longitudinal fibres.—The inner order of fibres is annular, without any observable angles.—The use of this coat, and these orders of fibres, is to promote deglutition; of which the longitudinal,—shorten the oesophagus, and so make its capacity larger to admit of the matter to be swallowed. The annular, on the contrary, contract the capacity, and closing behind the descending aliment, press it downwards. Drake's Anat. vol. i. l. 1. c. 9.

rious

rious as the food to be conveyed therein. And here I might describe the admirable mechanism of its tunics, muscles, glands, the nerves, arteries, and veins (*rr*); all manifesting the super-eminent contrivance and art of the infinite Workman (*ss*); they being all nicely adjusted to their respective place, occasion, and service. I might also insist upon that most necessary office of *digestion*; and here consider that wonderful faculty of the stomachs of all creatures, to dissolve (*tt*) all the several sorts of food appropriated to their species; even sometimes things of such consistency as seem insoluble (*uu*); especially by such seemingly simple and

(*rr*) See *Willis's Pharm. Rat.* part. 1. sect. 1. c. 2. *Cowper Anat. Tab.* 35. and many other authors.

(*ss*) *Promptuarium autem hoc, alimentum universum excipiens, ceu divinum, non humanum sit opificium.*—"This receptacle, in which every species of aliment is deposited, is so contrived as to indicate a skill far surpassing human art."—*Galen. de Usa. Part.* l. 4. c. 1.

(*tt*) *How great a comprehension of the nature of things, did it require, to make a menstruum, that should corrode all sorts of flesh coming into the stomach, and yet not the stomach itself, which is also flesh?* *Dr. Grew's Cosmol. Sacr.* c. 4.

(*uu*) The food of the *castor* being oftentimes, if not always, dry things, and hard of digestion, such as the roots and bark of trees, it is a wonderful provision made in that creature's stomach, by the digestive juice lodged in the curious little cells there. A description of whose admirable structure and order may be found in *Blasius* from *Wepfer*; concerning which he saith, *In quibus mucus reconditus, non secus ac mel in favis.*—*Nimirum quia castoris alimentum exsuccum, & coelu difficillimum est, sapientissimus & summè admirandus in suis operibus rerum Conditor,*
D. O. M.

and weak *menstruums* as we find in their stomachs: but I shall only give these things a bare mention, and take more peculiar notice of the special provision made in the particular species of animals, for the digestion of that special food appointed them *.

And

D. O. M. ipsi pulcherrimâ istâ & affabrè factâ structurâ benignissimè prospexit, ut nunquam deesset fermentum, quod ad solvendum, & comminuendum alimentum durum & asperum par foret.—"In which the *mucus* is laid up like the honey in a bee-hive.—For as the aliment of the castor or beaver is of a dry nature and of difficult digestion, the most wise and wonderful Author of Nature hath so constructed the stomach of the animal, that it is perpetually supplied with a fermenting juice which is fitted for dissolving and grinding down that hard and rugged aliment."—*Vide Blas. Anat. Animal, c. 10. Confer etiam Act. Erud. Lips. ann. 1684. p. 360.*

Most of our modern anatomists and physicians attribute digestion to a dissolving *menstruum*; but Dr. Drake takes it to be rather from fermentative, dissolving principles in the aliment itself, with the concurrence of the air and heat of the body; as in Dr. Papin's *Digester*. *Vide Dr. Anat. vol. i. c. 14.*

* At the time when Mr. Derham wrote these excellent discourses, a discovery had been but recently made of a class of animals, whose properties have since excited the admiration of the naturalist, and have served as a proof to the philosopher, of that nice gradation by which the several orders of organized bodies are connected with each other. What I here allude to is the tribe of animals called *polypi* or *hydræ*, which, while they vegetate like plants, and are capable of propagation by slips, are at the same time endowed with the most distinguishing properties of animal existence, as loco-motion which implies vo-

lition,

And in the first place it is observable, that, in every species of animals, the strength and size

of

lition, artifice in the search of, and modes of securing their prey, and an organization fitted like that of other animals, to digest and assimilate into its substance the nutritive particles of those insects on which they feed, and throw off their exuvizæ in excrement. The body of the polypus is one entire stomach.

These animals were first discovered by Mr. Lewenhock, who gave some account of them in the Philosophical Transactions for 1703; but their singular properties were but transiently noticed till 1740, when Mr. Trembley began to examine them. In 1742 Mr. Folkes gave an account of them to the Royal Society, and they have since been minutely analysed, and various experiments made on them by Mr. Baker, Mr. Adams, Mr. Bonnet, and others. There are seven varieties: 1. The *hydra viridis*, or green polype, which has commonly ten short arms. 2. The *fusca*, which has frequently eight arms several times longer than the body. 3. The *grisea*, which is of a yellowish colour, small towards the bottom, and has generally seven long arms. 4. The *pallens* has generally six arms of a moderate length. 5. The *hydratula* has a vesicular body, and four obsolete arms. It is found in the abdomen of sheep, swine, &c. 6. The *stentorea* which has been called the tunnel-shaped, and has a mouth surrounded with a row of hairs. 7. The *socialis vorticella*, or cluster-polype, is bearded, thick and wrinkled. (See Plate L.)

The three first species, on which the greatest number of experiments have been made, are very various in their forms. They are generally found in ditches in warm weather in the months of June, July, and August. When the sun is very powerful, an attentive observer will see on the surface of the water many little transparent gelatinous lumps of the size of a pea flattened on one side. They are likewise frequently attached to the under side of the leaves of plants. These are the polypes in a quiescent state, and apparently inanimate. They are generally

of their stomach (*ww*) is conformable to their food. Such whose food is more delicate, tender, and

(*ww*) *All carnivorous quadrupeds have the smallest ventricles, flesh going farthest. Those that feed on fruits and roots have them of a middle size. Yet the mole, because it feeds unclean, hath a very great one. Sheep and oxen, which feed on grass, have the greatest. Yet the horse (and for the same reason the coney and hare) though graminivorous, yet comparatively have but little ones. For that a horse is made for labour, and both this, and the hare, for quick and continued motion; for which, the most easy respiration, and so the freest motion of the diaphragm is very requisite; which yet could not be, should the stomach lie big and cumbersome upon it, as in sheep and oxen it doth.* Grew, ib. c. 6.

nerally fixed by one end to some solid substance, having at the other end a large opening, which is the mouth, around which are several arms projecting as rays from the centre. These arms are slender like the horns of a snail, pellucid, and capable of contraction or extension to a considerable length, as is likewise the whole body of the animal. With these arms they lay hold of small worms and other insects, bringing them to the mouth and swallowing them. The indigestible parts are again voided by the mouth. The progressive motion of these animals is performed by that power which they have of contracting or dilating their bodies. When desirous of moving, they bend down their head, and with their arms lay hold of some substance to which they mean first to fasten themselves; then they loosen their tail, and draw it towards the head; then either fix it in that place, or thrusting out their arms repeat the same operation. They sometimes hang by the tail on the surface of the water, the extremity of it becoming dry from the air, and thus capable of supporting them, on the same principle that a needle, when partly dry, swims upon the water.

The

and nutritive, have commonly this part thinner, weaker, and less bulky; whereas such whose aliment

The internal part of the animal seems to be entirely stomach; no vessels of any kind, or other viscera, being distinguishable. The skin of a polype, when examined with a microscope, appears like shagreen, being entirely covered with little grains. The structure of the arms is analogous to that of the body. That species called *fusca* has the longest arms, and makes use of the most curious manœuvres to seize its prey. Sometimes it spreads its arms to a considerable distance, inclosing and hooking to it whatever insect comes within the grasp of any of these arms. At other times it gives its arms a vibrating and rotatory motion, thus making a sort of whirlpool in the water, which brings to the centre where the animal's mouth is, whatever animal comes within its vortex. Sometimes a single arm is seen twisted like a cork-screw around an insect, which it immediately conveys to the mouth. When full, the polype contracts itself, hangs down as in a kind of stupor, but extends again in proportion as the food is digested, and the excrementitious part discharged. The food, when macerated and reduced into fragments, is driven backwards and forwards from one end of the animal to the other, and even into the arms and back again, all being evidently a hollow gut or stomach. The polypes feed on most insects found in fresh water. Sometimes two polypes lay hold of the same worm, and each begins to swallow its own end, till their mouths meet, and the worm is either broken, or the one polype devoured or drawn in by the other: but when this happens the polype is not digested, it is again returned alive through the mouth of its devourer. The natural mode in which the polypes generate, is by small tubercles proceeding from the side of the animal, which gradually increase in bulk, begin to push out arms, appear as if fastened only by the tail to the parent, and at length quit it altogether. The whole of this progress is sometimes
gone

ment is less nutritive, or whose bodies require larger supplies to answer their bulk, their labours, and

gone through in the space of twenty-four hours; at other times it takes several days. While the young animal is firmly attached to its parent, the food is seen to be circulated reciprocally from the one to the other, whatever is swallowed by the mouth of the one animal passing into the body of the other: this reciprocation has been observed to go on, while there was nine or ten young polypi sticking to the body of the parent. No intercourse of the sexes was ever observed to take place among these animals, nor does there seem to be any distinction of male and female.

The most singular phenomena attending this class of animals is their propagation by slips or cuttings. If a polypus is cut into twenty pieces, each piece will in a short time produce a perfect animal. Even the smallest portion of the skin of a polype, an arm, or a fragment of a young sprout while attached to the body of its parent, grows in a very short time a complete polype of the same species. Two polypi may be grafted together; the head of one will unite with the body of another whose head has been cut off; or if brought in union with the tail, an animal will be formed with two heads. The *hydra fusca* may be turned outside in, like a glove, without any apparent injury to the animal functions, which go on as before. If the animal has young ones attached to its outside when this operation is performed, they grow in the inside till they come out at the mouth, and thus detach themselves from the parent. The *socialis*, or clustering polype, appears like a circle surrounded with crowns or ciliated heads tied by small thin tails to a common centre, from which they advance towards the circumference, and then turn like a wheel, making a vortex which draws in the food to the mouth.

It is now perfectly ascertained, that the marine substances called corals, corallines, *keratophyta*, eschera, sponges, &c. are in

and waste of strength and spirits, in them it is large and strong.

Another very remarkable thing in this part, is, the number of ventricles in divers creatures *. In many but one; in some two or more (xx). In such as make a sufficient comminution of the food in their mouth, one suffices. But where teeth are wanting, and the food dry and hard, (as in granivorous birds,) there the defect is abundantly supplied by one thin membranaceous ventricle, to receive and moisten the food, and another thick, strong, muscular one, to grind and tear (yy) it. But in such birds, and other creatures, whose food is not grain, but flesh, fruits, insects, or partly one, partly the other, there their stomachs are accordingly

(xx) The *dromedary* hath four stomachs, one whereof is peculiarly endowed with about twenty cavities, like sacks, in all probability for the holding of water. Concerning which, see *book vi. chap. 4. note (a)*.

(yy) To assist in which office, they swallow small angular stones, which are to be met with in the gizzards of all granivorous birds; but in the gizzard of the *ixnx*, or *wryneck*, which was full only of *ants*, I found not one stone. So in that of the *green wood-pecker* (full of *ants* and tree-maggots) there were but few stones.

in reality the cases formed by polypi of different kinds, for their habitation and defence. See the works of Peyssonnel, Ellis, Jussieu, Reaumur, Donati, and others. EDITOR.

* It has been already observed (*ante*, p. 28.) that the animals of the hydra or polype species, seem to consist internally of nothing else but stomach, without viscera or vessels of any kind.

EDITOR.

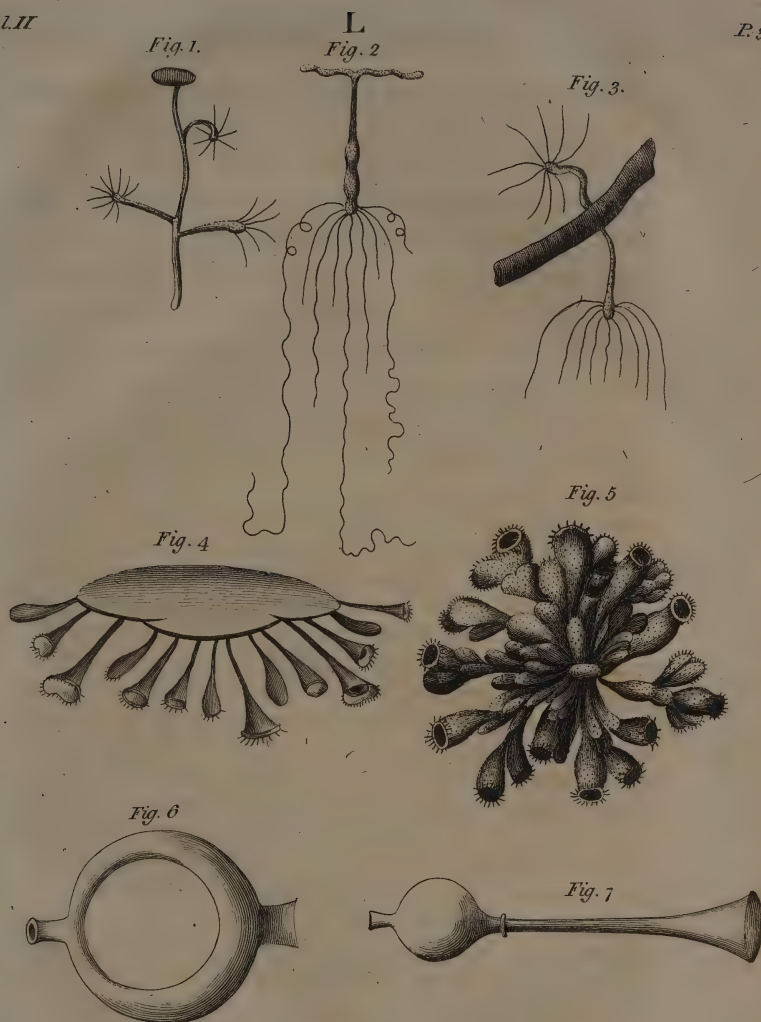


Fig. 1. the *Hydra viridis* or green Polype. Fig. 2 the *Hydra fusca*. Fig. 3. the *Hydra-Grisea*. Fig. 4. the *Stentorea* or funnel polype. Fig. 5 The *Socialis, vorticella* or Cluster-polype.

Fig. 6. the Horn used by Alexander the Great to assemble his army.

Fig. 7. a *Stentorophenic Horn* of Kircher's invention.

ingly conformable to their food (zz), stronger or weaker, membranaceous or muscular *.

But as remarkable a thing as any in this part of animals is, the curious contrivance and fabric of the several ventricles of ruminating creatures. The very act itself of *rumination*, is an excellent provision for the complete mastication of the food, at the resting, leisure times of the animal. But the apparatus for this service, of divers ventricles for its various uses and purposes, together with their curious mechanism, deserves great admiration (aaa).

(zz) *In most carnivorous birds, the third ventricle is membranous; where the meat is concocted, as in a man: or somewhat tendinous, as in an owl; as if it were made indifferently for flesh, or other meat, as he could meet with either. Or most thick and tendinous, called the gizzard; wherein the meat, as on a mill, is ground to pieces. Grew, ubi supra, c. 9.*

(aaa) It would be much too long a task to insist upon it here as it deserves, and therefore concerning the whole business of rumination, I shall refer to *J. Conr. Peyer's Merycolog. seu de Ruminantibus & ruminatione Commentar.* where he largely treateth of the several ruminating animals, of the parts ministering to this act, and the great use and benefit thereof unto them.

* Animals whose food requires much comminution, and who have no apparatus in their mouth for that purpose, have it, as already observed, in the stomach. As, for example, the crab and lobster, and granivorous fowls, have a powerful gizzard, lined with a thick corneous substance. This stomach likewise has a compressing force, like that of the jaws, and the small pebbles which the animals swallow serve it for teeth.

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Having thus far pursued the food to the place, where, by its reduction into chyle, it becomes a proper aliment for the body; I might next trace it through the several meanders of the *guts*, the *laeteals*, and so into the *blood* (*bbb*), and afterwards into

(*bbb*) There are too many particulars to be insisted on, observable in the passages of the *chyle*, from the guts to the *left subclavian vein*, where it enters into the blood; and therefore I shall only, for a sample of this admirable œconomy, take notice of some of the main and more general matters. And,

1. After the food is become chyle, and gotten into the guts, it is an excellent provision made, not only for its passage through the guts, but also for its protrusion into the *laeteals*, by the *peristaltic* motion, and *valvule conniventes* of the guts. 2. It is an admirable provision, that the mouths of the *laeteals*, and indeed the *laeteals primi generis* themselves, are small and fine, not wider than the *capillary arteries* are, lest, by admitting particles of the nourishment grosser than the *capillaries*, dangerous obstructions might be thereby produced. 3. After the reception of the aliment into the *laeteals primi generis*, it is a noble provision for the advancement of its motion, that in the *mesenteric glands*, it meets with some of the *lymphæ-ducts*, and receives the impregnations of the *lymphæ*. And passing on from thence, it is no less advantage, 4. That the *laeteals*, and *lymphæ-ducts* meet in the *receptaculum chyli*, where the aliment meeting with more of the *lymphæ*, is made of a due consistence and temperament, for its farther advancement through the *thoracic duct*, and so into the *left subclavian vein* and blood. Lastly, This *thoracic duct* itself is a part of great consideration. For, (as Mr. Cowper saith,) If we consider in this duct its several divisions and inosculations, its numerous valves looking from below upwards, its advantageous situation between the great artery and vertebræ of the back, together with the ducts discharging their reflux lymphæ from the lungs, and other neighbouring parts, we shall find all conduce to demonstrate the utmost

into the very habit of the body : I might also take notice of the separation made in the *intestines* of what is nutritive, (which is received,) and what is feculent (being ejected); and the impregnations there from the *pancreas* and the *gall*; and after it hath been strained through those curious colanders, the *lacteal veins*, I might also observe its impregnations from the *glands* and *lymphæ-duets*; and, to name no more, I might farther view the exquisite structure of the parts ministring to all these delicate offices of nature; particularly the artificial conformation of the intestines might deserve a special enquiry, their tunicks, glands, fibres traversing one another (*ccc*), and peristaltick motion in all creatures; and their cochleous passage (*ddd*) to retard the motion of the chyle, and to make amends for the shortness of the intestines, in such creatures as

most art of Nature used in furthering the steep and perpendicular ascent of the chyle. Anat. Introduct.

(*ccc*) These, although noble contrivances and works of God, are too many to be insisted on, and therefore I shall refer to the anatomists, particularly Dr. *Willis Pharmaceut.* Dr. *Cole*, in *Phil. Transf.* No. 125. and Mr. *Cowper's* elegant cut in *Anat. Tab.* 34, 35. and *Append. fig.* 39, 40.

(*ddd*) In the *thornback*, and some other fishes, it is a very curious provision that is made to supply the paucity and brevity of the guts; by the perforation of their single gut, going not straight along, but round like a pair of winding-stairs; so that their gut, which seems to be but a few inches long, hath really a bore of many inches. But of these, and many other noble curiosities and discoveries in anatomy, the reader will, I hope, have a better and larger account from the curious and ingenious Dr. *Douglas*, who is labouring in those matters.

have but one gut; together with many other accommodations of nature in particular animals that might be mentioned. But it shall suffice to have given only a general hint of those curious and admirable works of God. From whence it is abundantly manifest, how little weight there is in the former atheistical objection. Which will receive a further confutation from the

VI. and last thing relating to food, that I shall speak of, namely, *The great sagacity of all animals, in finding out and providing their food.* In man, perhaps, we may not find any thing very admirable, or remarkable in this kind, by means of his reason and understanding, and his supremacy over the inferior creatures; which answereth all his occasions relating to this business: but then even here the Creator hath shewed his skill, in not over-doing the matter; in not providing man with an unnecessary apparatus, to effect over and over again what is feasible, by the reach of his understanding, and the power of his authority.

But for the inferior creatures, who want reason, the power of that natural instinct, that sagacity (eee) which the Creator hath imprinted upon them, do

(eee) *Quibus bestiis erat is cibus, ut alius generis bestiis vescerentur, aut vires natura dedit, aut celeritatem: data est quibusdam etiam machinatio quædam, atque solertia, &c.*—"Those beasts who live upon such food as is likewise adapted to the nourishment of other sorts of animals, are endowed by nature with either strength or swiftness: some have likewise a superior degree of artifice and sagacity." *Cic. de Nat. Deor. l. 2. c. 48.*

amply

B

Fig. 1.

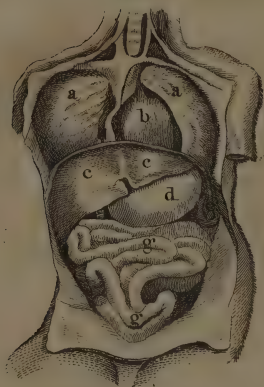


Fig. 2.

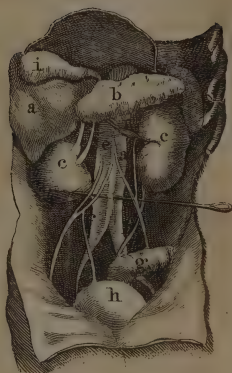


Fig. 3.



Fig. 4.

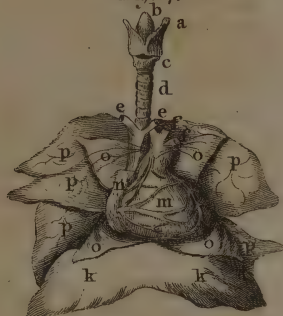


Fig. 1. Shews the contents of the Thorax and Abdomen. aa the lungs. bb the heart cc the liver. d the stomach. e the spleen. g the Jejunum and Ilium.

Fig. 2. Shews the organs subservient to the Chylipoietic viscera, with those of Urine and Generation. a the Liver. b the Pancreas. cc the kidneys. d the Aorta. e the Vena cava. f the Ureters. g Rectum. h the Bladder i the Gall-bladder.

Fig. 3. Shews the Chylipoietic viscera and organs subservient to them, taken out of the body entire. aa the two lobes of the liver, b the gall-bladder. c the Stomach d the spleen. e Mesocolon. f Colon. g Jejunum and Ilium. h Rectum intestinum. i levatores ani sphincter ani.

Fig. 4 The viscera of the Thorax, viz. the Heart & Lungs, with the situation of the great veins & arteries. a b c, the Larynx. d Aspera arteria. e e the subclavian veins f f the subclavian artery. m the Heart. n the right auricle of the heart. o o the pericardium laid open. p p p p the Lungs, k k the diaphragm.



amply compensate that defect. And here we shall find a glorious scene of the Divine wisdom, power, providence, and care, if we view the various instincts of beasts, great and small, of birds, insects, and reptiles (*fff*). For among every species of them, we may find notable acts of sagacity, or instinct, proportional to their occasions for food *. Even among those

(*fff*) Among reptiles that have a strange faculty to shift for food, &c. may be reckoned *eels*, which, although belonging to the waters, can creep on the land from pond to pond, &c. Mr. *Moseley* of *Moseley*, saw them creep over the meadows, like so many snakes from ditch to ditch; which he thought, was not only for bettering their habitation, but also to catch snails in the grass. *Plot's History of Staffordshire*, c. 7. sect. 32.

And as early as the year 1125, the frost was so very intense, that the *eels* were forced to leave the waters, and were frozen to death in the meadows. Vide *Hakewill's Apol.* l. 2. chap. 7. sect. 2.

* Animals that have short legs, and are thus not fitted by nature for pursuing their prey, make up for that defect by their cunning and sagacity. The *carcajou* of North America, or glutton, which is an animal of the weasel kind, but of a large size and extremely voracious, and whose prey is the elk and reindeer, would be utterly incapable of ever attaining its object by speed of foot; for its motions are extremely slow. It therefore singles out a tree on which it perceives the marks of the teeth or antlers of the deer, and climbing up hides itself among the thick branches. There it remains with the greatest patience often for many days, till the elk or reindeer chances to pass immediately under, when dropping down upon his back it fixes its claws between his shoulders, and remains there unalterably rivetted. It is in vain that the large affrighted animal increases its speed, or threatens with its branching horns; the glutton having taken possession

those whose food is near at hand, and easily come at; as grafs and herbs; and consequently have no great need of art to discover it; yet, that faculty of their accurate smell and taste, so ready, at every turn, to distinguish between what is salutary, and what pernicious (ggg), doth justly deserve praise. But

(ggg) *Enumerare possum, ad pastum capeffendum conficiendumque, quæ sit in figuris animantium & quàm solers, subtilisque descriptio partium, quàmque admirabilis fabrica membrorum. Omnia enim quæ intus inclusa sunt, ita nata, atque ita locata sunt, ut nihil eorum supervacaneum sit, nihil ad vitam retinendam non necessarium. Dedit autem eadem Natura belluis & sensum, & appetitum, ut altero conatum haberent ad naturales pastus capeffendos; altero secernerent pestifera à salutaribus.*—"I might enumerate all the ingenious and subtile contrivances in those parts of animals which serve for seeking and consuming their food; and likewise the admirable structure of all their members. All the interior parts are so formed and placed, that there is nothing superfluous, nothing but what is absolutely necessary for carrying on the vital functions. Nature has likewise furnished animals with sense and appetite; the one for disposing them to take their natural food, and the other for enabling them to discriminate between what is salutary and what is noxious." *Cic. de Nat. Deor. l. 2. c. 37.* See book iv. c. 4.

possession of its post, nothing can drive it off; its enormous prey drives rapidly along among the thickest woods, rubs itself against the largest trees, and tears down the branches with its expanded horns; but still its insatiate foe sticks behind, eating its neck, and digging its passage to the large blood vessels that lie in that part. When the deer at length falls down with faintness from loss of blood, the voracious foe then begins his feast: he eats on without intermission till his belly is distended to an enormous size, he becomes incapable of any other animal function,

But for such animals, whose food is not so easily come at, a variety of wonderful instinct may be met with, sufficient to entertain the most curious observer. With what entertaining power and artifice do some creatures hunt (*bbb*), and pursue their game and prey *. And others watch and way-lay theirs !

(*bbb*) It would be endless to give instances of my own and others observations, of the prodigious sagacity of divers animals in hunting, particularly hounds, setting-dogs, &c. one therefore shall suffice of Mr. Boyle's, viz. *A person of quality, to make a trial, whether a young blood-hound was well instructed, caused one of his servants to walk to a town four miles off, and then to a market-town three miles from thence. The dog, without seeing the man he was to pursue, followed him by the scent to the above-mentioned places, notwithstanding the multitude of market-people that went along in the same way, and of travellers that had occasion to cross it. And when the blood-hound came to the chief market-town, he passed through the streets, without taking notice of any of the people there, and left not till he had gone to the house, where the man he sought rested himself, and found him in an upper room, to the wonder of those that followed him.* Boyle determ. Nat. of Effluv. chap. 4.

function, and lies totally torpid for three or four days by the side of the carcase ; waking at intervals from his lethargy, and renewing his meal with the same voracity, till at length he has eat up the enormous animal, bones and all. During the continuance of this loathsome banquet, which lasts for several days, the intolerable stench which he sends forth is a sufficient protection against all invaders. When the prey is completely consumed, the glutton betakes himself again to his post, to wait with patience for a fresh supply to his appetite. EDITOR,

* This artifice in watching for and securing their prey is equally conspicuous in some of the minute insects, as in the larger animals. Of this there cannot be a more striking example

theirs (iii)! With what prodigious sagacity do others grope for it under ground, out of sight, in

(iii) There are many stories told of the craft of the *fox*, to compass his prey; of which *Ol. Magnus* hath many such, as feigning the barking of a *dog*, to catch prey near houses; feigning himself dead, to catch such animals as come to feed upon him; laying his tail on a wasp-nest, and then rubbing it hard against a tree, and then eating the *wasps* so killed: ridding himself of *fleas*, by gradually going into water, with a lock of wool in his mouth, and so driving the *fleas* up into it, and then leaving it

than in the insect called *formica leo*, or the lion pismire, which is the caterpillar or worm of a fly, resembling the libellæ or dragon flies. This creature is remarkable for constructing a most artful snare for entrapping those insects which are his prey. He chooses for his residence a dry spot, generally under the shelter of a wall, where the soil is of a fine sand. He first traces a circle on the surface of the sand which is to be the mouth of the pit which he intends to form. Placing himself in the centre of this circle, he buries himself all but the head in the sand, which, with his two horns or antennæ, he throws up with a whirling motion towards the circumference of the circle, repeating this operation till he has formed the whole inner part of his circle into the shape of a funnel or inverted cone of loose sand, on which no insect, however small, can set its feet without pushing down some of its small particles into the centre. This serves as a warning to the animal that his prey is within the limits of his snare, and he immediately whirls up the sand that covers his head in a cloud that envelopes the insect entirely, prevents all its attempts to escape, and brings it down by the weight thrown above to the centre of the funnel, where it is immediately destroyed and drained of all its juices. The object of this extraordinary creature is now to remove the exsiccated carcase, which it does by throwing it out with a violent circular jerk beyond the limits of the funnel, that its spoils may not be seen to deter others from approaching the den of this devourer.

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in moorish places, in mud and dirt (*kkk*); and others dig and delve for it, both above (*lll*), and under

it in the water: by catching *crab* fish with his tail, which he saith he himself was an eye-witness of: *Vidi & ego in scopulis Norvegia vulpem, inter rupes immissâ caudâ in aquas, plures educere caneros, ac demum devorare.*—"I saw a fox among the rocks in Norway, who by plunging his tail into the water, drew out crabs that fastened to it, and then devoured them." *Ol. Mag. Hist.*

l. 18. c. 39, 40.

But *Pliny's* fabulous story of the *hyena* out-does these relations of the fox, *Sermonem humanum inter pastorum stabula assimulare, nomenque alicujus addiscere, quem evocatum foras laceret. Item vomitionem hominis imitari ad sollicitandos canes quos invadat.*—

"The hyena is wont to repair to the shepherds' huts and imitate the human voice, and even learn some person's name, who when he answers to the call and comes out, is immediately torn in pieces. Nay they will imitate the sound of a person vomiting, so as to entice the dogs about them, and then devour them *."

Plin. Nat. Hist. l. 8. c. 30.

(*kkk*) This do *ducks*, *woodcocks*, and many other fowls, which seek their food in dirty, moorish places. For which service they have very remarkable nerves reaching to the end of their bills. Of which see *book vii. chap 2. note (e)*.

(*lll*) *Swine*, and other animals that dig, have their noses made more tendinous, callous, and strong for this service, than others that do not dig. They are also edged with a proper, tough border, for penetrating and lifting up the earth; and their nostrils are placed well, and their smell is very accurate, to discover whatsoever they pursue by digging.

* There is a species of fish which actually shoots its prey; and is thence termed *jaculator*. It frequents the sea shores and the mouths of rivers. When it spies a fly sitting on the plants that grow in shallow water, it swims to within five or six feet of the place, and then with surprising dexterity it darts from its tubular

under the surface of the drier lands (*mmm*)! And how curious and well designed a provision is it of

(*mmm*) The *mole*, as its habitation is different from that of other animals, so hath its organs in every respect curiously adapted to that way of life; particularly its nose made sharp and slender, but withal tendinous and strong, &c. But what is very remarkable, it hath such nerves reaching to the end of its
nose

tubular mouth a single drop of water, which never fails striking the fly into the sea, where it immediately becomes its prey. This fish is described by Linnæus under the name of *chaetodon*. It frequents the shores of the islands of Java and Sumatra. A most singular species of instinct is found in the *cuculus indicator*, or honey guide, a bird which forms an association with man to search for its appropriate food. This bird is a native of Africa, and subsists on wild honey, but unable of itself to attack and storm a nest of bees, it flies before the traveller, calling in a shrill voice *cher cher*, a note which the honey-hunters carefully attend to, as the summons for the chase. From time to time they answer with a soft whistle, which the bird hearing, always continues its note; and if it happens to outfly the hunters, it returns to them again, and redoubles its note, as if reproaching them for their inactivity. At length it is observed to hover and flutter for some minutes over a certain spot, and then silently retiring to a neighbouring bush, the hunters are sure of finding the bees in that identical spot, either in a hollow tree or in the earth. While they are busy in taking the honey, the bird is seen looking on attentively, and waiting for its share of the spoil, which the hunters never fail to leave for it; but commonly not enough to satisfy its appetite, in order that it may be thence incited to a new chase. Dr. Sparman, in the Philosophical Transactions for 1777, informs us that he has been witness to many of those chases: and that having shot one of the birds, he thereby excited the utmost indignation of the Hottentots, who cherish the species for their own advantage.

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particular

particular large nerves in such creatures, adapted to that especial service!

What an admirable faculty is that of many animals, to discover their prey at vast distances; some by their smell some miles off (*nnn*); and some by their sharp and piercing sight, aloft in the air, or at other great distances (*ooo*)! An instance of the latter of which God himself giveth, (*Job xxxix. 27, 28, 29.*) in the instinct of the eagle: *Doth the eagle mount up at thy command, and make her nest on high? She dwelleth and abideth on the rock, upon the crag of the rock, and the strong place (ppp). From thence*

nose and lips, as *ducks*, &c. have, mentioned above in note (*kkk*). Which pair of nerves I observed to be much larger in this animal than any other nerves proceeding out of its brain.

(*nnn*) Predacious creatures, as *wolves*, *foxes*, &c. will discover prey at great distances; so will *dogs* and *ravens* discover carrion a great way off by their smell. And if (as the superstitious imagine) the latter flying over and haunting houses be a sign of death, it is no doubt from some cadaverous smell, those *ravens* discover in the air by their accurate smell, which is emitted from those diseased bodies, which have in them the principles of a speedy death.

(*ooo*) Thus *hawks* and *kites* on land, and *gulls*, and other birds, that prey upon the waters, can at a great height in the air see *mice*, little birds and insects on the earth, and small fishes, *shrimps*, &c. in the waters, which they will dart down upon, and take.

(*ppp*) Mr. Ray gives a good account of the nidification of the *chrysaëtos caudâ annulo albo cinctâ*. *Hujus nidus ann. 1668. in sylvis prope Derwentiam, &c. inventus est, è bacillis seu virgis ligneis grandioribus compositus, quorum altera extremitas rupis cujusdam eminentiæ, altera duabus betulis innitebatur,—erat nidus quadratus,*

thence she seeketh her prey, and her eyes behold afar off. What a commodious provision hath the contriver of nature made for animals, that are necessitated to climb for their food ; not only in the structure of their legs and feet, and in the strength of their tendons and muscles, acting in that particular office (*qqq*) ; but also in the peculiar structure of the principal parts, acting in the acquirement of their

quadratus, duas ulnas latus. In eo pullus unicus, adjacentibus cadaveribus unius agni, unius leporis, & trium grygallorum pullorum.—

“ Of the golden eagle with a white ring about its tail. Its nest was found in the year 1668 in the woody country about the Derwent : it was composed of pretty large sticks and branches, and one end of it rested on the extremity of a rock, the other upon two birch trees. The nest was of a square form, and two ells broad. In it there was a single young one, and close by it lay the carcases of a lamb, a hare, and three young moor-fowl.”

Synops. Method. Avium, p. 6. And not only lambs, hares, and grygalli, but Sir Robert Sibbald tells us, they will seize kids and fawns ; yea, and children too : of which he hath this story of an eagle in one of the Orcadès islands. *Quæ infantulum unius anni pannis involutum arripuit (quem mater tessellas usibiles pro igne allatura momento temporis deposuerat) in loco Houton-hed dicto eumque deportasse per 4 milliaria passuum ad Hoiam ; quâ re ex matris ejulationibus cognitâ, quatuor viri illuc in naviculâ profecti sunt, & scientes ubi nidus esset, infantulum illesum & intactumprehenderunt.—*“ In a place named Houton-hed, an eagle seized an infant of a year old, wrapt up in its clothes, which the mother had laid down while she went to fetch turf for her fire, and carried it to the distance of four miles into an island called Hoy. The mother’s cries giving the alarm immediately, four men took a boat, and knowing the spot where the nest was, they luckily brought off the child safe and unhurt.” *Prod. Nat. Hist. Scot.* l. 3. part 2. p. 14.

(*qqq*) See in book vii. chap. 1. note (1), the characteristics of the woodpecker kind.

food !

food (*rrr*)! What a provision also is that in nocturnal birds and beasts, in the peculiar structure of their eye (*sss*), (and we may perhaps add the accuracy of their smell too,) whereby they are enabled to discover their food in the dark? But among all the instances we have of natural instinct, those instincts, and especial provisions made to supply the necessities of helpless animals, do in a particular manner demonstrate the great Creator's care. Of which I shall give two instances.

I. The provision made for young creatures. That *Στοργή*, that natural affection, so connatural to all, or most creatures towards their young (*ttt*),
what

(*rrr*) *The contrivance of the legs, feet, and nails [of the opossum] seem very advantageous to this animal in climbing trees (which it doth very nimbly) for preying upon birds. But that which is most singular in this animal, is the structure of its tail, to enable it to hang on boughs. The spines, or hooks, in the middle of the under side of the vertebræ of the tail, are a wonderful piece of Nature's mechanism. The first three vertebræ had none of these spines, but in all the rest they were to be observed. They were placed just at the articulation of each joint, and in the middle from the sides. For the performing this office [of hanging by the tail] nothing, I think, could be more advantageously contrived. For when the tail is twirled or wound about a stick, this hook of the spinæ easily sustains the weight, and there is but little labour of the muscles required, only enough for bowing or crooking the tail. This, and more to the same purpose, see in Dr. Tyson's Anatomy of the Opossum, in Philosophical Transact. No. 239.*

(*sss*) See before chap. 2. note (*z*), (*aa*), (*bb*).

(*ttt*) *Quid dicam quantus amor bestiarum sit in educandis custodiendisque iis, quæ procreaverint, usque ad eum finem, dum possint seipsa defendere?—*“What need is there to mention the extraordinary

what an admirable noble principle is it, implanted in them by the wise Creator? By means of which, with

ordinary affection that animals shew in rearing and protecting their young, till they are able to take care of themselves?" And having instanced in some animals, where this care is not necessary, and accordingly is not employed, he goes on, *Fam gallinæ, avesque reliquæ, & quietum requirunt ad pariendum locum, & cubilia sibi, nidusque construunt, eosque quàm possunt mollissimè substerunt, ut quàm facillimè ova serventur. Ex quibus pullos cum excluderint, ita tuentur, ut & pennis foveant, ne frigore lædantur, & si est calor, à sole se opponant.*—"Hens and other fowls require a quiet place to lay their eggs in, and they form their nests as soft as possible, to preserve them from injury. When the young are hatched, they guard them from all harm: they cherish them with their plumage to keep them in heat, and when the heat of the sun is extreme, they screen them from it with their bodies." *Cic. de Nat. Deor. l. 2. c. 51, 52.*

To this natural care of parent-animals to their young, we may add the returns made by the young of some towards the old ones. *Pliny* saith of rats, *Genitores suos fessos senectâ, alunt insigni pietate.*—"They show an extraordinary care and affection in nourishing their aged parents."—*Nat. Hist. l. 8. c. 57.* So *Cranes*, he saith, *Genetricum senectam invicem educant.*—"In their turn they afford support to their parents in old age." *L. 10. c. 23.*

This *St. Ambrose* takes notice of in his *Hexameron*, and *Ol. Magnus* after him, *Depositi patris artus, per longævum senectutis plumis nudatos circumspiciens soboles pennis propriis fovet,—collatitio cibo pascit, quando etiam ipsa naturæ reparat dispendia, ut hinc inde senem sublevantes, fulcro alarum suarum ad volandum exerceant, & in pristinos usus desueta membra reducant.*—"The young cover and cherish with their wings, the featherless limbs of the aged crane. They feed him with the food they have collected, and sometimes even raise him up and carry him on their wings, to give exercise to his languid body, and bring in some degree his worn-out limbs again into use and action." For which reason this bird is denominated *pia*. *Vide Ol. Mag. Hist. l. 19. c. 14.*

Heretb

with what alacrity do they transact their parental ministry? With what care do they nurse up their young; think no pains too great to be taken for them, no dangers (*uuu*) too great to be ventured upon for their guard and security*. How carefully will they lead them about in places of safety, carry them into places of retreat and security; yea, some

Hereto may be added also the conjugal *Στοργή* of the little green *Æthiopian parrot*, which Mr. Ray describes from *Clusius*. *Femellæ senescentes (quod valdè notabile) vix edere volebant, nisi cibum jam à mare carptum, & aliquandiu in prolobo retentum, & quasi coctum rostro suo exciperent, ut columbarum pulli à matre ali solent.*—"The female, when she grows old, will scarcely taste food, unless it is procured her by the male, and is kept awhile in his beak, and thus macerated for her; in the same manner as we see the young pigeons fed by their mother." *Synops. Meth. Av. p. 32.*

(*uuu*) The most timid animals, that at other times abscond, or hastily fly from the face of man, dogs, &c. will for the sake of their young expose themselves. Thus among fowls, *hens* will assault, instead of fly from such as meddle with their brood. So *partridges*, before their young can fly, will drop frequently down, first at lesser, and then at greater distances, to dodge and draw off dogs from pursuing their young.

* The care of animals (says lord Kaimes) to preserve their young from harm, is a beautiful instance of Providence. When a hind hears the hounds, she puts herself in the way of being hunted, and leads them away from her fawn. The lapwing is no less ingenious: if a person approach, she flies about, retiring always from her nest. A partridge is extremely artful: she hops away, hanging a wing as if broken; lingers till the person approach, and hops again. The roebuck defends its young with resolution and courage. So doth the ram, and so do many other quadrupeds. *Sketches of the History of Man, book i. sk. 6.* A fox has been known to run for several miles, carrying her cub in her mouth when pursued by the hounds.

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of

of them admit them into their own bowels (*www*)? How will they careſs them with their affectionate notes, lull and quiet them with their tender parental voice, put food into their mouths, fuckle them, cheriſh and keep them warm, teach them to pick, and eat, and gather food for themſelves; and, in a word, perform the whole part of ſo many nurſes, deputed by the ſovereign Lord and Preſerver of the world, to help ſuch young and ſhiftleſs creatures, till they are come to that maturity, as to be able to ſhift for themſelves?

And as for other animals, (particularly inſects, whoſe fire is partly the ſun, and whoſe numerous offspring would be too great for their parent-animal's care and proviſion,) theſe are ſo generated, as to need none of their care, by reaſon they arrive immediately to theiſt *ἡλικία*, their perfect, adult ſtate, and are able to ſhift for themſelves. But yet, thus far their parental inſtinſt (equivalent to the moſt rational care and foreſight) doth extend, that the old ones do not wildly drop their eggs and ſperm any where, at all adventures, but ſo cau-

(*www*) The *opoffum* hath a curious bag on purpoſe for the ſecuring and carrying about her young. There are belonging to this bag two bones (not to be met with in any other ſkeleton) and four pair of muſcles; and ſome ſay the teats lie there-in alſo. Dr. *Tyſon*. *Anat. of the Opoff.* in *Phil. Trans.* No. 239. where he alſo, from *Oppian*, mentions the *dog-fiſh*, that upon any ſtorm or danger, receives the young ones into her belly, (ſee Plate F, fig. 1.) which come out again when the fright is over. So alſo the *ſquatina* and *glaucus*, the ſame author ſaith, have the ſame care for their young, but receive them into different recep-tacles.

tiouſly

tiously reposit it in such commodious places (some in the waters, some on flesh, some on plants, proper and agreeable to their species (xxx); and some shut up proper nutriment in their nests, partly for incubation, partly for food (yyy),) that their young in their *aurelia*, or *nympha* state, may find sufficient and agreeable food to bring them up, till they arrive at their maturity.

Thus far the parental instinct and care.

Next we may observe no less in the young themselves, especially in those of the irrational animals. Forasmuch as the parent-animal is not able to bear them about, to cloath them, and to dandle them, as man doth; how admirably hath the Creator contrived their state, that those poor young creatures can soon walk about, and with the little helps of their dam shift for, and help themselves? How naturally do they hunt for their teat, suck, pick (zzz) and take in their proper food?

But for the young of man, their parents reason, joined with natural affection, being sufficient to

(xxx) See *book viii. chap. 6.* (yyy) See *chap. 13. note (c).*

(zzz) There is manifestly a superintending Providence in this case, that some animals are able to suck as soon as ever they are born, and that they will naturally hunt for the teat before they are quite gotten out of the secundines, and parted from the navel-string, as I have seen. But for *chickens*, and other young birds, they not being able immediately to pick till they are stronger, have a notable provision made for such a time, by a part of the yolk of the egg being inclosed in their belly, a little before their exclusion or hatching, which serves for their nourishment, till they are grown strong enough to pick up meat. Vide *book vii. chap. 4. note (a).*

help, to nurse, to feed, and to cloath them; therefore they are born helpless, and are more absolutely, than other creatures, cast upon their parents care (aaaa): a manifest act and designation of the Divine Providence.

2. The other instance I promised, is the provision made for the preservation of such animals as are sometimes destitute of food, or in danger of being so. The winter is a very inconvenient, improper season, to afford either food or exercise to insects, and many other animals. When the flowery fields are divested of their gaiety; when the fertile trees and plants are stripped of their fruits, and the air, instead of being warmed with the cherishing beams of the sun, is chilled with rigid frost; what would become of such animals as are impatient of cold? what food could be found by such as are subsisted by the summer-fruits? But to obviate all this evil, to stave off the destruction and extirpation of divers species of animals, the infinitely wise Preserver of the world hath as wisely ordered the matter; that, in the first place, such as are impatient of cold, should have such a special structure of their body, particularly of their hearts, and circulation of their

(aaaa) *Qui [infantes] de ope nostrâ ac de divinâ misericordiâ plus merentur, qui in primo statim nativitatis suæ ortu plorantes ac flentes, nil aliud faciunt quàm deprecantur.*—"Infants have the greater claim to the divine aid and to the kindness of man, that, from the moment of their birth, they can do nothing but implore mercy by their wailings and feeble cries."—*Cypr. Ep. ad Fid.*

blood,

blood (bbbb), as during that season; not to suffer any waste of their body, and consequently not to need any recruits; but that they should be able to live in a kind of sleepy, middle state, in their places of safe retreat, until the warm sun revives both them and their food together.

The next provision is for such as can bear the cold, but would want food then; and that is in some by a long patience of hunger * (cccc), in others by

(bbbb) I might name here some of the species of birds, the whole tribe almost of insects, and some among other tribes, that are able to subsist for many months without food, and some without respiration too, or very little: but it may suffice to instance only the *land-tortoise*, of the structure of whose heart and lungs, see *book vi. chap. 5. note (b)*.

(cccc) *Inediam diutissime tolerat lupus, ut & alia omnia carnivora, licet voracissima; magnâ utique Nature providentiâ; quoniam esca non semper in promptu est.*—"The wolf can endure hunger for a very long time, as can all other carnivorous animals; even the most voracious of them: and in this the providence of Nature is most conspicuous; for their food is not always readily procured."—*Ray's Synops. Quadr. p. 174.*

To the long abstinence mentioned of brute animals, I hope the reader will excuse me, if I add one or two instances of extraordinary abstinence among men. One *Martha Taylor*, born in *Derbyshire*, by a blow on the back fell into such a prostration of appetite, that she took little sustenance, but some drops with a feather, from *Christmas 1667*, for thirteen months, and slept but little too all the time. See *Dr. Sampson's* account thereof in *Ephem. Germ. T. 3. Obs. 173.*

To

* *Dr. Goldsmith*, who (as the excellent epitaph composed for him by his friend *Johnson* truly notes) *nihil quod tetigit non ornavit,*

by their notable instinct in laying up food beforehand against the approaching winter (dddd). Of this

To this we may add the case of *S. Chilton*, of *Tinsbury* near *Bath*, who in the years 1693, 1696, and 1697, slept divers weeks together. And although he would sometimes, in a very odd manner, take sustenance, yet would lie a long time without any, or with very little; and all without any considerable decay. See *Phil. Transf.* No. 304.

(dddd) They are admirable instincts which the *Sieur de Beauplau* relates of his own knowledge, of the little animals called *bo-hagues* in *Ukraine*. They make burroughs like rabbits, and in October shut themselves up, and do not come out again till April. They spend all the winter under ground, eating what they laid up in summer. Those that are lazy among them, they lay on their backs, then lay a great handful of dry herbage upon their bodies, &c. then others drag those drones to the mouths of their burroughs, and so those creatures serve instead of barrows, &c. I have often seen them practise this, and have had the curiosity to observe them whole days together. Their holes are parted like chambers; some serve for storehouses, others for burying-places, &c. Their government is nothing inferior to that of bees, &c. They never go abroad without posting a sentinel upon some high ground, to give notice to the others whilst they are feeding. As soon as the sentinel sees any body, it stands upon his hind-legs and whistles.—*Beauplau's Description of Ukraine*, in vol. i. of the *Collection of Voyages*, &c.

A like instance of the northern galli sylvestres, see in chap. 13. note (g).

As for the scriptural instance of the ant, see hereafter book viii. chap. 5. note (d).

ornavit,—“adorned every subject which he handled,”—has the following beautiful remarks on the wonderful abstinence of brute animals from food and sleep. “Every animal that we are acquainted with seems to endure the want of these with much less injury to health than man; and some are more surprisingly patient in sustaining both. The little domestic animals that we keep about us, may often set a lesson of calm resignation in sup-
porting

this many entertaining examples may be given; particularly we may, at the proper season, observe not only the little treasures and holes well stocked with timely provisions, but large fields (eeee) here and

(eeee) I have in *autumn*, not without pleasure, observed, not only the great sagacity and diligence of *swine*, in hunting out the stores of the *field-mice*; but the wonderful precaution also of those little animals, in hiding their food beforehand against winter. In the time of acorns falling, I have, by means of the *bogs*, discovered, that the *mice* had, all over the neighbouring fields, treasured up single acorns in little holes they had scratched, and in which they had carefully covered up the acorn. These the *bogs* would, day after day, hunt out by their smell.

porting want and watchfulness to the boasted philosopher. They receive their pittance at uncertain intervals, and wait its coming with cheerful expectation. We have instances of the dog and the cat living in this manner without food for several days; and yet still preserving their attachment to the tyrant that oppresses them; still ready to exert their little services for his amusement or defence. But the patience of these is nothing to what the animals of the forest endure. As these mostly live upon accidental carnage, so they are often known to remain without food for several weeks together. Nature, kindly solicitous for their support, has also contracted their stomachs to suit them for their precarious way of living, and kindly, while it abridges the banquet, lessens the necessity of providing for it."—*Goldsmith's Hist. of the Earth and animated Nature.*

The length of time during which some animals remain alive without food, is strongly exemplified by the following fact:—Vaillant, in the introduction to his Travels through the interior Parts of Africa, informs us, that he inclosed a large garden spider under a glass bell, well fastened round the bottom with cement, and left it in that situation for ten months together. It appeared alert and

and there throughout bespread with considerable numbers of the fruits of the neighbouring trees, laid carefully up in the earth, and covered safe, by the provident little animals inhabiting thereabouts. And not without pleasure have I seen and admired the sagacity of other animals, hunting out those subterraneous fruits, and pillaging the treasures of those little provident creatures.

And now from this bare transient view of this branch of the great Creator's providence and government, relating to the *food* of his creatures, we can conclude no less, than that since this grand œconomy hath such manifest strokes of admirable and wise contrivance; that since this is demonstrated throughout all ages and places, that therefore it is God's handy-work. For how is it possible that so vast a world of animals should be supported, such a great variety equally and well supplied with proper food, in every place fit for habitation, with-

vigorous during the whole period, and exhibited no other alteration of appearance than that its belly, which at first was of the size of a nut, became at last no bigger than the head off a pin. He then put another spider under the same bell. At first they kept at a distance from each other; but presently the meagre one approached and attacked the stranger, returning at intervals to the charge, and in these conflicts never failed to carry off a leg or a claw of its antagonist, which it greedily devoured, increasing gradually in plumpness. At length the new-comer deprived of all means of defence was entirely devoured, and the old inhabitant became as round within the space of a single day, as at the first moment of its confinement."

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out

out an especial superintendency and management, equal to, at least, that of the most prudent steward and householder? How should the creatures be able to find out their food when laid up in secret places? And how should they be able to gather even a great deal of the common food, and at last to macerate and digest it, without peculiar organs adapted to the service? And what less than an infinitely wise God could form such a set of curious organs, as we find every species endowed with, for this very use? Organs so artificially made, so exquisitely fitted up, that the more strictly we survey them, the more accurately we view them, (even the meanest of them with our best glasses,) the less fault we find in them, and the more we admire them: whereas the best polished and most exquisite works, made by human art, appear through our glasses as rude and bungling, deformed and monstrous; and yet we admire them, and call them works of art and reason. And lastly, What less than rational and wise could endow irrational animals with various instincts, equivalent, in their special way, to reason itself? Insomuch that some from thence have absolutely concluded, that those creatures had some glimmerings of reason. But it is manifestly instinct, not reason they act by, because we find no varying, but that every species doth naturally pursue at all times the same methods and way, without any tutorage or learning: whereas *reason*, without instruction, would often vary, and do that by many methods, which *instinct* doth by one alone. But of this more hereafter.

CHAP. XII.

Of the Cloathing of Animals.

HAVING in the foregoing chapter somewhat largely taken a view of the infinite Creator's wisdom and goodness towards his creatures in ordering their food, I shall be more brief in this chapter, in my view of their *cloathing* (a); another necessary appendage of life, and in which we have plain tokens of the Creator's art, manifested in these two particulars; the *suitableness of animals cloathing to their place and occasions* *; and the *garmenture and beauty thereof*.

(a) Concerning the *cloathing of animals*, *Aristotle* observes, *that such animals have hair as go on feet, and are viviparous; and that such are covered with a shell as go on feet, and are oviparous.* Hist. Anim. l. 3. c. 10

I. The

* The universal custom (says an ingenious author) of the inhabitants of all countries in which the temperature of the atmosphere is below the standard of the heat of the human body making use of apparel, and this being thicker or thinner in proportion to the respective differences of seasons or climates, is founded on the principle of preventing such an escape of heat from the body as would be either unpleasant or injurious to it. The same thing may be observed of the natural cloathing of different animals; in warm climates their coats are short; smooth, and lie close to the skin; but in the northern regions, their
covering

I. The cloathing of animals is suited to their place of abode, and occasions there; a manifest act of design and skill. For if there was a possibility, that animals could have been accoutered any other way, than by the God that made them, it must needs have come to pass, that their cloathing

covering consists of a rarer substance, as fur, wool, &c. In birds this circumstance is peculiarly striking: as they pass freely through the air, and are often exposed in the higher regions to a very cold medium, their natural heat would pass off much too quickly, if they were not covered with a substance which conducts heat very slowly, which feathers are well known to do. And in those birds which live in water, which withdraws heat much quicker than air, their covering is much more rare and compact than common feathers; the down upon the breast, and under the bellies of those birds, which in cold climates live principally in the water, being perhaps the slowest conductors of heat in Nature. Modern luxury having on this principle set a great value on the down of the *eider-duck*, and its use in retaining heat; for which reason it is applied in fits of the gout, as also, on account of its extraordinary lightness, a purpose for which it is particularly well adapted, as the parts affected are usually so tender as to suffer pain from the slightest pressure. The slow conducting powers of this down being evidently owing to its rare texture, it is obvious that, to retain this quality, it should remain perfectly dry; as the plumage, when wet, will very soon collapse together and form a body capable of carrying off heat too quickly. To guard against this circumstance Nature has furnished these aquatic birds with a peculiar kind of *oil*, and has given them the power of occasionally opening the receptacle where it is deposited, and of spreading a sufficient quantity of it over their outermost feathers, by which the contact of water is effectually prevented. *Medical Extracts*, part. 2. p. 99.

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would

would have been at all adventures, or all made the same mode and way, or some of it, at least, inconvenient and unsuitable. But on the contrary, we find all is curious and complete, nothing too much, nothing too little, nothing bungling, nothing but what will bear the scrutiny of the most exquisite artist; yea, and so far out-do his best skill, that his most exquisite imitations, even of the meanest hair, feather, scale, or shell, will be found only as so many ugly ill-made blunders and botches, when strictly brought to the test of good glasses. But we shall find an example remarkable enough in the present case, if we only compare the best of cloathing which man makes for himself, with that given by the Creator for the covering of the irrational creatures. Of which it may be said, as our Saviour doth of the flowers of the field, *Matt. vi. 29. That even Solomon, in all his glory, was not arrayed like one of these.*

But let us come to particulars, and consider the suitableness of the different methods the Creator hath taken in the cloathing of man, and of the irrational animals. This *Pliny* (b) pathetically laments,

(b) *Cujus [hominis] causâ videtur cuncta alia genuisse Natura, magnâ & sevâ mercede contra tanta sua munera: ut non sit satis estimare, parens melior homini, an tristior noverca fuerit. Ante omnia unum animantium cunctorum alienis velat opibus: ceteris variè tegumenta tribuit, testas, cortices, coria, spinas, villos, setas, pilos, plumam, pennas, squamas, vellera. Truncos etiam arboreosque cortice, interdum gemino, à frigoribus, & calore tutata est. Hominem tantum nudum, & in nudâ humo, natali die abjicit ad vagitus statim*
& pla-

ments, and says, *It is hard to judge, whether Nature hath been a kinder parent, or more cruel step-mother to man.* For, says he, *Of all creatures, he alone is covered with other's riches, whereas Nature hath given various cloathing to other animals, shells, hides, prickles, shag, bristles, hair, down, quills, scales, fleeces; and trees she hath fenced with a bark or two against the injuries of cold and heat. Only poor naked man, says he, is in the day of his birth cast into the wide world, to immediate crying and squalling; and none of all creatures besides, so soon to tears in the very beginning of their life.*

But here we have a manifest demonstration of the care and wisdom of God towards his creatures; that such should come into the world with their bodies ready furnished and accommodated,

Et ploratum, nullumque tot animalium aliud ad lacrymas, Et has protinus vitæ principio. Plin. Nat. Hist. l. 7. Proem.

Let Seneca answer this complaint of Pliny, although perhaps what he saith might be more properly noted in another place: *Quisquis es iniquus estimator sortis humane, cogita quanta nobis tribuerit Parens noster, quanto valentiora animalia sub jugum miserimus, quanto velociora assequamur, quam nihil sit mortale non sub ictu nostro positum. Tot virtutes accepimus, tot artes, animum denique cui nihil non eodem quo intendit momento pervium est, sideribus velociorem, &c.*—“Whoever thou art who formest this unjust estimate of the lot of Man, reflect with thyself upon those powers by which he has brought the strongest animals under subjection, and has apprehended and caught the swiftest, that nothing in short, which is endued with life, is exempt from his power and dominion. Such talents have we received from our Creator, so powerful, so penetrating a mind, &c.—*Senec. de Benef. l. 2, c. 29.*

who

who had neither reason nor forecast to contrive, nor parts adapted to the artifices and workmanship of cloathing; but for man, he being endowed with the transcending faculty of reason, and thereby made able to help himself, by having thoughts to contrive, and withal hands to effect, and sufficient materials (c) afforded him from the skins of animals, and from various trees and plants: man,

(c) *Mirantur plurimi quomodo tutè, & sanè vivant homines in horrendis frigoribus plagæ Septentrionalis; hancque levem questionem ultra 30 annos audieram in Italiâ, præsertim ab Æthiopibus, & Indis, quibus onerosus videtur vestitus sub Zonâ torridâ.—Quibus respondetur,—gaudet Indus multiplici plumarum genere, magis forsan pro tegumento, quàm necessitate: rursus Scythia villosa vestitu.—Ita sub polo Arctico adversus asperrimas hyemes—opportuna remedia faciliter administrat [Natura], ligna videlicet in maximâ copiâ, & levissimo pretio, & demum pelles diversorum animalium, tam sylvestrium quàm domesticorum.—“There are many who wonder how men can live in those dreadful cold countries of the North; and this frivolous observation I have heard 30 years ago in Italy, chiefly from those of India and Ethiopia, to whom the northern cloathing appears heavy and cumbrous. To these it may be answered: the Indian wears his feathers chiefly for ornament; the Scythian, his fur garment for use and from necessity. In the Arctic regions, Nature supplies convenient resources against the cold; wood in abundance, and at no price; and likewise the skins and furs of domestic and of wild animals.”—Then he gives a catalogue of them; and saith, *Quarum omnium experti pellifices ita ingeniosè noverunt mixturas componere, ut pulcherrimum decorem ostendat varietas, & calidissimum fomentum adjuncta mollities.*—“Of all these, expert furriers make ingenious mixtures, and artfully combine the various colours so as to answer at once the purposes of ornament and of use.”—*Ol. Mag. Hist. l. 6. c. 20.**

To this guard against the cold, namely, of fire and cloathing, I hope the reader will excuse me, if I take this opportunity of adding

man, I say, having all this provision made for him, therefore the Creator hath wisely made him

adding some other defensatives Nature (or rather the great Author of Nature) hath afforded these northern regions: such are their high mountains, abounding, as *Ol. Magnus* saith, through all parts; also, their numerous woods, which besides their fire, do, with the mountains, serve as excellent screens against the cold piercing air and winds. Their prodigious quantities of minerals, and metals, also afford heat, and warm vapours, *Mineræ septentrionalium regionum satis multæ, magnæ, diversæ, & opulenti sunt*,—"The minerals of the northern countries are various in kind, abundant in quantity, and extremely rich,"—saith the same curious, and (for his time) learned archbishop. *L. 6. c. 1.* and in other places. And for the warmth they afford, the *volcano's* of those parts are an evidence; as are also their terrible thunder and lightning, which are observed to be the most severe and mischievous in their metalline mountains, in which large herds of cattle are sometimes destroyed; the rocks so rent and shattered, that new veins of silver are thereby discovered; and a troublesome kind of quinsie is produced in their throats, by the stench and poisonous nature of the sulphureous vapours, which they dissolve, by drinking warm beer and butter together, as *Olaus* tells us in the same book, *chap. 11.*

To all which defensatives, I shall, in the last place add, the warm vapours of their lakes (some of which are prodigiously large, of 130 *Italian* miles in length, and not much less in breadth); also of the rivers, especially the vapours which arise from the sea. Of which guard against severe cold, we have lately had a convincing proof in the *great frost* in 1708, wherein, when *England, Germany, France, Denmark*; yea, the more southerly regions of *Italy, Switserland*, and other parts, suffered severely; *Ireland* and *Scotland* felt very little of it, hardly more than in other winters; of the particulars of which, having given an account in the *Philos. Transf.* No. 324, I shall thither refer the reader. But it seems, this is what doth ordinarily

him naked, and left him to shift for himself, being so well able to help himself.

And a notable act this is of the wisdom of **GOD**, not only as the more setting forth his care and kindness to them that most needed his help, the helpless irrational animals, and in his not overdoing his work; but also as it is most agreeable to the nature and state of man (*d*), both on natural and political accounts. That man should cloath

ordinarily befall those northern parts, particularly the *Islands of Orkney*, of which the learned *Dr. Wallace* gives this account: *Here the winters are generally more subject to rain than snow; nor doth the frost and snow continue so long here as in other parts of Scotland; but the wind in the mean time will often blow very boisterously; and it rains sometimes, not by drops, but by spouts of water, as if whole clouds fell down at once. In the year 1680, in the month of June, after great thunder, there fell flakes of ice near a foot thick.*—*Wall. Account of Orkney, ch. i. p. 4.*—From which last passage I observe; that although in those parts the atmosphere near the earth be warm, it is excessively cold above, so as to freeze some of those spouts of water in their descent into such great and almost incredible masses of hail. And whence can this warmth proceed, but from the earth, or sea, emitting heat sufficient to flave off the cold above: consult *book ii. chap. 5. note (c)*.

(*d*) *Sicut enim si innata sibi [i. e. homini] aliqua haberet arma, illa ei sola semper adessent, ita & si artem aliquam Natura sortitus esset, reliquas sanè non haberet. Quia verò ei melius erat omnibus armis, omnibusque artibus uti, neutrum eorum à Naturâ ipsi propterea datum est.*—"For if man were furnished by Nature with any species of arms for defence, he would never want these, it is true; but then he would have no other: thus if he inherited from Nature any particular art, he would be deprived of all others: but it was more wisely determined, that as he was to use all sorts of arms, and to be versant in all arts, he should inherit none of them directly from Nature."—*Galen. de Us. Part. l. i. c. 4.*

himself,

himself, is most agreeable to his nature, particularly (among other things) as being most salutary and most fuitable to his affairs. For by this means, man can adapt his cloathing to all seasons, to all climates, to this or to any business. He can hereby keep himself sweet and clean, fence off many injuries; but above all, by this method of cloathing, with the natural texture of his skin adapted to it, it is that grand means of health, namely, *insensible perspiration* (e), is performed, at least greatly promoted, without which an human body would be soon over-run with disease.

In the next place, there are good political reasons for man's cloathing himself, inasmuch as his industry is hereby employed in the exercises of his art and ingenuity; his diligence and care are

(e) Concerning *insensible perspiration*, *Sanctorius* observes, that it much exceeds all the sensible put together. *De Stat. Med. Aph. 4.* That as much is evacuated by *insensible perspiration* in one day, as is by *stool* in fourteen days. Particularly, that, in a night's time, about sixteen ounces is commonly sent out by *urine*, four ounces by *stool*; but above forty ounces by *insensible perspiration*. *Aphor. 59, 60.* That if a man eats and drinks eight pounds in a day, five pounds of it is spent in *insensible perspiration*, *sect. 1. Aph. 6.* And as to the times, he saith, *Ab assumpto cibo 5 horis 11. circiter perspirabilis—exhalare solet, à 5a ad 12am 3l. circiter; à 12a ad 16am vix selibram. Aph. 56.*

And as to the wonderful benefits of *insensible perspiration*, they are abundantly demonstrated by the same learned person, *ubi supra*; as also by *Borelli* in his second part, *De Mot. Animal. prop. 168.* who saith, *Necessaria est insensibilis transpiration, ut vita animalis conservetur.*—"The insensible perspiration is necessary for preserving the life of the animal."

exerted

exerted in keeping himself sweet, cleanly, and neat; many callings and ways of life arise from thence, and (to name no more) the ranks and degrees of men are hereby in some measure rendered visible to others, in the several nations of the earth.

Thus it is manifestly best for man that he should cloath himself.

But for the poor shiftless irrationals, it is a prodigious act of the great Creator's indulgence, that they are already furnished with such cloathing, as is proper to their place and business (*f*). Some covered with hair (*g*), some with feathers (*b*), some with

(*f*) *Animantium verò quanta varietas est. Quanta ad eam rem vis, ut in suo quæque genere permaneant? Quarum aliæ coriis testæ sunt, aliæ villis vestitæ, aliæ spinis hirsutæ: plumâ alias, alias squamâ videmus obductas, alias esse cornibus armatas, alias habere effugia pennarum.*—"How great is the variety of animals? How powerful is Nature in thus maintaining and perpetuating so many distinct species? Some clothed with skin, others with hair or wool, a third species defended by prickles, a fourth covered with feather, a fifth with scales: some horned, and others winged."—*Cic. de Nat. Deor. l. 2. c. 47.*

(*g*) From *Malpighi's* curious observations of the hair, I shall note three things: 1. Their structure is fistulous or tubular; which hath long been a doubt among the curious. *Fistulosum [esse pilum] demonstrant lustratio pilorum à caudâ & collo equorum, &c.—præcipuè setarum apri, quæ patentiores ex fistulis compositionem exhibent. Est autem dictus apri pilus cylindricum corpus quasi diaphanum—fistularum aggere conflatum, & speciem columnæ striatæ præ se fert. Componentes fistulæ in gyrum situatæ in apice patentiores redduntur; nam hians pilus in geminas dividitur partes, & componentes minimæ fistulæ—liberiores redditæ manifestantur,*
ita

with scales, some with shells (*i*), some only skin, and some with firm and stout armature; all nicely accom-

ita ut enumerari possunt; has autem 20, & ultra numeravi.—Expositæ fistulæ—tubulosæ sunt, & frequentibus tunicis transversaliter situatis, veluti valvulis pollent. Et quoniam spinæ, in erinaceis præcipuè, &c. nil aliud sunt, quam duri & rigidi pili, ideo, &c.
 “That hairs are tubular, appears from examining those of a horse’s tail or mane.—The bristles of a hog exhibit very large and open pipes. They form a cylindrical and transparent body like a cluster of pipes joined together in the manner of a striated column. The component pipes, when separated, become more apparent, and can be easily counted. I have counted above twenty of them,” &c.—And then he describes the hedgehog’s spines, in which those tubes manifestly appear; together, with medullary valves and cells, not inelegant, which he hath figured in *tab. 16*, at the end of his works.

That which this sagacious, and not enough to be commended observer took notice of in the structure of hair, and its parity to the spines, I have myself observed in some measure to be true, in the hair of *cats, rats, mice*, and divers other animals, which look very prettily when viewed with a good microscope. The hair of a *mouse* (the most transparent of any I have viewed) seems to be one single transparent tube, with a pith made up of a fibrous substance, running in dark lines; in some hairs transversely, in others spirally, as in *Plate F, fig. 2, 3, 4, 5*. These darker medullary parts or lines, I have observed, are no other than small fibres convolved round, and lying closer together than in other parts of the hair. They run from the bottom to the top of the hair; and, I imagine, serve to the gentle evacuation of some humour out of the body; perhaps, the hair serves as well for the *insensible perspiration* of hairy animals, as to fence against cold and wet. In *fig. 2.* and *3.* is represented the hair of a *mouse*, as it appears through a small magnifier; and in *fig. 4.* and *5.* as it appears when viewed with a larger magnifier.

accommodated to the element in which the creature liveth, and its occasions there (*k*). To *quadrupeds* hair is a commodious cloathing; which, together with the apt texture of their skin, fitteth them for all weathers, to lie on the ground, and to do the offices required by man; and the thick and warm furs and fleeces of others, are not only a good defensative against the cold and wet, but also a soft bed to repose themselves in; and to many of them, a comfortable covering, to nurse and cherish their tender young.

And as hair to quadrupeds, so feathers are as commodious a dress to such as fly in the air, to birds, and some insects; not only a good guard against wet and cold, and a comfortable covering to such as hatch and brood their young, but

Upon another review, I imagine, that although in *fig. 14*, and *4*. the dark parts of the pith seem to be transverse; that they, as well as in the two other figures, run round in a screw-like fashion.

(*i*) See *chap. 14. note (c)*.

(*k*) It is a sign some wise Artist was a Contriver of the cloathing of animals; not only as their cloathing varies, as their way of living doth; but also because every part of their bodies is furnished with proper suitable cloathing. Thus divers animals, that have their bodies covered for the most part with short smooth hair, have some parts left naked, where hair would be an annoyance: and some parts beset with long hair, as the mane and tail: and some with stiff strong bristles, as about the nose: and sometimes within the nostrils, to guard off, or give warning of annoyances,

also

also most commodious for their flight. To which purpose they are nicely and neatly placed every where on the body, to give them an easy passage through the air (*l*), and to assist in the wafting their body through that thin medium. For which service, how curious is their texture for lightness, and withal for strength? hollow and thin for lightness, but withal, context and firm for strength. And where it is necessary they should be filled, what a light and strong medullary substance is it they are filled with? by which curious contrivances, even the very heaviest parts made for strength, are so far from being a load to the body, that they rather assist in making it light and buoyant, and capacitate it for flight. But for the vanes, the lightest part of the feather, how curiously are they wrought with capillary filaments, neatly interwoven together (*m*), whereby they are not only light, but also sufficiently close and strong, to keep

(*l*) The feathers being placed from the head towards the tail, in close and neat order, and withal preened and dressed by the contents of the oil-bag, afford as easy a passage through the air, as a boat new cleansed and dressed finds in its passage through the waters. Whereas, were the feathers placed the contrary, or any other way, (as they would have been, had they been placed by chance, or without art,) they would then have gathered air, and been a great encumbrance to the passage of the body through the air. See *book vii. chap. 1. note (b)*.

(*m*) In *book vii. chap. 1. note (e)*, there is a particular account of the mechanism of their vanes, from some nice microscopical observations, and therefore I shall take no farther notice of it here.

the body warm, and guard it against the injuries of weather, and withal to impower the wings, like so many sails, to make strong impulses upon the air in their flight (*n*). Thus curious, thus artificial thus commodious is the cloathing of beasts and birds : concerning which, more in proper place.

And no less might I shew that of reptiles and fishes (*o*) to be, if it was convenient to enlarge upon this branch of the Creator's works. How well adapted are the *annuli* of some reptiles, and the contortions of the skin of others, not only to fence the body sufficiently against outward injuries, but to enable them to creep, to perforate the earth (*p*),

(*n*) Vide *Borell. de Mot. Animal.* prop. 182. vol. i.

(*o*) See *book ix.*

(*p*) For a sample of this branch of my Survey, let us choose the tegument of *earth-worms*, which we shall find completely adapted to their way of life and motion, being made in the most complete manner possible for terebrating the earth, and creeping where their occasions lead them. For their body is made throughout of small rings, and these rings have a curious *apparatus* of muscles, enabling those creatures with great strength to dilate, extend, or contract their *annuli*, and whole body; those *annuli* also are each of them armed with small, stiff, sharp *beards* or *prickles*, which they can open, to lay hold on, or shut up close to their body: and lastly, under the skin there lies a *slimy juice*, that they emit, as occasion is, at certain perforations between the *annuli*, to lubricate the body, and facilitate their passage into the earth. By all which means they are enabled with great speed, ease, and safety, to thrust and wedge themselves into the earth; which they could not do, had their bodies been covered with hair, feathers, scales, or such like cloathing of the other creatures. See more concerning this animal, *book ix. chap. i. note (a).*

and,

and, in a word, to perform all the offices of their reptile state, much better than any other tegument of the body would do? and the same might be said of the covering of the inhabitants of the waters, particularly the shells of some, which are a strong guard to the tender body that is within, and consistent enough with their slower motion; and the scales and skins of others, affording them an easy and swift passage through the waters. But it may be sufficient to give only a hint of these things, which more properly belong to another place.

Thus hath the indulgent Creator furnished the whole animal world with convenient suitable cloathing.

II. Let us, in the next place, take a short view of the *garniture* (*q*) and *beauty* thereof. And here we shall thus far, at least, descry it to be beautiful; that it is complete and workman-like. Even the cloathing of the most sordid animals, those that are the least beautified with colours, or rather whose cloathing may regrade the eye (*r*); yet when

(*q*) *Aristotle*, in his *Hist. Anim.* l. 3. c. 12. names several rivers, that by being drank of, change the colour of the hair.

(*r*) For an example, let us take the cloathing of the *tortoise* and *viper*; because, by an incurious view, it rather regradeth, than pleaseth the eye: but yet, by an accurate survey, we find the shells of the former, and the scales of the latter, to be a curious piece of mechanism, neatly made; and so completely and well put, and tacked together, as to exceed any human compositions: of the latter, see more in *book ix. chap. 1. note (c)*.

we come strictly to view them, and seriously consider the nice mechanism of one part, the admirable texture of another, and the exact symmetry of the whole; we discern such strokes of inimitable skill, such incomparable curiosity, that we may say with *Solomon*, Eccl. iii. 11. [GOD] *hath made every thing beautiful in his time.*

But for a farther demonstration of the super-eminent dexterity of his Almighty Hand, he hath been pleased, as it were on purpose, to give surprising beauties to divers kinds of animals. What radiant colours are many of them, particularly some birds and insects (*s*), bedeck'd with! what a prodigious combination is there often of these, yea; how nice an air frequently of meaner colours (*t*), so as to captivate the eye of all beholders, and exceed the dexterity of the most exquisite pencil to copy?

And now, when we thus find a whole world of animals, cloathed in the wisest manner, the most suitable to the element in which they live, the

(*s*) It would be endless to enter into the particulars of the beautiful *birds* and *insects* of our *European* parts; but especially those inhabiting the countries between the tropics, which are observed as much to exceed our birds in their colours, as ours do theirs in their singing.

(*t*) The *uryneck*, at a distance, is a bird of mean colour; neither are indeed its colours radiant or beautiful, singly considered: but when it is in the hand we see its light and darker colours so curiously mixed together, as to give the bird a surprising beauty. The same is also observable in many insects, particularly of the *phalena*-kind.

place

place in which they reside, and their state and occasions there; when those that are able to shift for themselves, are left to their own discretion and diligence, but the helpless well accoutered and provided for; when such incomparable strokes of art and workmanship appear in all, and such inimitable glories and beauties in the cloathing of others; who can, without the greatest obstinacy and prejudice, deny this to be God's handy-work? The gaudy, or even the meanest apparel, which man provideth for himself, we readily enough own to be the contrivance, the work of man: and shall we deny the cloathing of all the animal world besides (which infinitely surpasseth all the robes of earthly majesty; shall we, dare we, deny that) to be the work of any thing less than of an infinite, intelligent Being, whose art and power are equal to such glorious work!

C H A P. XIII.

Of the Houses and Habitation of Animals.

HAVING in the last chapter, as briefly as well I could, surveyed the *cloathing* of animals, I shall in this take a view of their *houses, nests, their cells and habitations*; another thing no less necessary to their well-being than the last; and in which the great Creator hath likewise signalized his care and skill, by giving animals an architectonic faculty, to build themselves convenient places of retirement, in which to repose and secure themselves, and to nurse up their young.

And here, as before, we may consider the case of man, and that of the irrational animals. Man having (as I said) the gift of reason and understanding, is able to shift for himself, to contrive and build, as his pleasure leads him, and his abilities will admit of. From the meanest huts and cottages, he can erect himself stately buildings, bedeck them with exquisite arts of architecture, painting, and other garniture; ennoble them, and render them delightful with pleasant gardens, fountains, avenues, and what not? for man therefore the Creator hath abundantly provided in this respect, by giving him an ability to help himself. And a wise provision this is, inasmuch as it is an excellent

lent exercise of the wit, the ingenuity, the industry and care of man.

But since ingenuity, without materials, would be fruitless, the materials therefore which the Creator hath provided the world with, for this very service of building, deserve our notice. The great varieties of trees (*a*), earth, stones, and

(*a*) — *Dant utile lignum*

Navigiis pinos, domibus cedrosque, cupressosque :
Hinc radios trivere rotis, hinc tympana plaustriis
Agricolæ, & pandas ratibus posuere carinas.
Viminibus salices sæcundæ, frondibus ulmi ;
At myrtus validis hastilibus, & bona bello
Cornus : Ityæos taxi torquentur in arcus.
Nec tilia leves, aut torno rasile buxum,
Non formam accipiunt, ferroque cavantur acuto :
Necnon & torrentum undam levis innatat alnus
Missa Pado : necnon & apes examina condunt
Corticibusque cavis, vitiosæque ilicis alveo.

VIRG. Georg. l. 2. carm. 442.

“ Yet heaven their various plants for use designs ;
 For houses, cedars, and for shipping, pines.
 Cypress provides for spokes and wheels of wains,
 And all for keels of ships that scour the wat’ry plains.
 Willows in twigs are fruitful, elms in leaves,
 The war from stubborn myrtle shafts receives ;
 From cornels javelins, and the tougher yew
 Receives the bending figure of a bow.
 Nor box nor limes without their use are made
 Smooth-grain’d, and proper for the turner’s trade,
 Which curious hands may carve, and steel with ease
 invade. }

Light alder stems the Po’s impetuous tide,
 And bees in hollow oaks their honey hide.”

DRYDEN’S VIRG.

plants,

plants, answering every occasion and purpose of man for this use, in all ages and places all the world over, is a great act of the Creator's goodness; as manifesting, that since he has left man to shift for himself, it should not be without sufficient help to enable him to do so, if he would but make use of them, and the sense and reason which God hath given him.

Thus sufficient provision is made for the habitation of man.

And no less shall we find is made for the rest of the creatures; who, although they want the power of reason to vary their methods, and cannot add to, or diminish from, or any way make improvements upon their natural way; yet we find that natural instinct, which the Creator's infinite understanding hath imprinted in them to be abundantly sufficient, nay, in all probability, the very best or only method they can take, or that can be invented for the respective use and purpose of each peculiar species of animals (*b*). If some creatures make their nests in houses, some in trees, some in shrubs, some in the earth (*c*), some in

(*b*) See *chap. 15. and book viii. chap. 6.*

(*c*) Many of the *vespa-ichneumones* are remarkable enough for their nidification and provision for their young. Those that build in earth, (who commonly have golden and black rings round their *alvi*,) having lined the little cells they have perforated, lay therein their eggs, and then carry into them maggots from the leaves of trees, and seal them up close and neatly. And another *ichneumon*, more of the *vespa* than *musca-ichneumon* kind, (having a little sting in its tail, of a black colour,)

in stone, some in the waters, some here, and some there, or have none at all; yet we find, that that place, that method of nidification doth abundantly answer the creatures use and occasions. They can there sufficiently and well repose, and secure themselves, lay, and breed up their young. We are so far from discovering any inconvenience in any of their respective ways, from perceiving any loss befall the species, any decay, any perishing of their young; that in all probability, on the contrary, in that particular way they better thrive, are more secure, and better able to shift for, and help themselves. If, for instance, some beasts make

lour) gave me the pleasure, one summer, of seeing it build its nest in a little hole in my study-window. This cell was coated about with an odoriferous, resinous gum, collected, I suppose, from some fir-trees near; after which it laid two eggs, (I think the number was,) and then carried in divers maggots, some bigger than itself. These it very sagaciously sealed close up into the nest, leaving them there, doubtless, partly to assist the incubation; and especially for food to the future young when hatched.

Of this artifice of these *ichneumons*, *Aristotle* himself takes notice (but I believe he was scarce aware of the eggs sealed up with the spiders). *Οι δὲ Σφήκες Ιχνεύμονες καλύμμενοι, &c.* As to the vespæ, called *ichneumones*, (*less than others*,) they kill spiders, and carry them into their holes, and having sealed them up with dirt, they therein hatch, and produce those of the same kind. *Hist. Anim. l. 5. c. 20.*

To what hath been said about these *ichneumon wasps*, I shall add one observation more, concerning the providential structure of their mouth in every of their tribes, *viz.* their jaws are not only very strong, but nicely sized, curved, and placed for gnawing and scraping those complete little holes they perforate in earth, wood, yea in stone itself.

to themselves no habitation, but lie abroad in the open air, and there produce their young; in this case we find there is no need it should be otherwise, by reason they are either taken care of by man (*d*), or in no danger, as other creatures, from abroad. If others repose their young in holes (*e*) and dens, and secure themselves also therein, it is, because such guard, such security is wanting, their lives being sought either by the hostility of man, or to satisfy the appetite of rapacious creatures (*f*). If among birds, some build their nests close, some open, some with this, some with another material, some in houses, some in trees, some on the ground (*g*), some on rocks and crags on high

(*d*) Tully having spoken of the care of some animals towards their young, by which they are nursed and brought up, saith, *Accedit etiam, ad nonnullorum animantium, & earum rerum quas terra gignit, conservationem, & salutem, hominum etiam solertia & diligentia. Nam multe & pecudes, & stirpes sunt, quæ sine procuratione hominum salvæ esse non possunt.*—"The care and attention of man is likewise employed for the preservation of certain classes of both living creatures and vegetable productions. For there are many animals and many plants which could not be safe without the attention of man."—*Cic. de Nat. Deor. l. 2. c. 52.*

(*e*) Prov. xxx. 26. *The conies are but a feeble folk, yet make they their houses in the rocks.*

(*f*) See note (*l*).

(*g*) It is a notable instinct which *Ol. Magnus* tells of the *Galli Sylvestres*, in his northern country, to secure themselves against the cold and storms of the winter. *Cùm nives instar collium terræ superficiem ubique cooperiunt, ramosque arborum diutius deprimunt & condensant, certos fructus betule arboris—in formâ longi*

high (of which God himself hath given an instance in the *eagle*, Job. xxxix. 27, 28). And so among the insect and reptile kinds, if some repose their eggs or young in the earth, some in wood, some in stone, some on one kind of plant, some on another, some in warm and dry places, some in the water and moist places, and some in their own bodies only, as shall be shewn in proper place; in all these cases it is, in all probability, the best or only method the animal can take for the hatching and production of its young, for their supplies, safety, or some other main point of their being or well-being. This is manifest enough in many cases, and therefore probable in all. It is manifest that such animals, for instance, as breed

longi piperis vorant, & glutunt indigestos; idque tantâ aviditate, ac quantitate, ut repletum guttur toto corpore majus appareat. Deinde partitis agminibus sese inter medios nivium colles immergunt, præsertim in Jan. Febr. Martio, quando nives ut turbines, typhones, vel tempestates gravissimæ nubibus descendunt. Cumque coopertæ sunt, —certis hebdomadis cibo in gutture collecto, egesto, & resumpto vivunt venatorum canibus non produntur.—“ When the snow covers the earth to a great depth, and weighs down the branches of the trees for a long space of time, these birds devour a great quantity of the fruit of the birch tree which resembles long pepper, and gorge themselves with it so that their craw appears equal in size to their whole body. Then, separating into flocks, they immerge themselves in the snow-hillocks; chiefly in the months of January, February, and March, when the snows descend in whirlwinds and tempests. Thus covered up they are able to live for weeks together by means of the food they have accumulated in their craws, and they are not discovered by the hunter’s dogs.”—*Ol. Mag. Hist.* l. 19. c. 33.

in

in the waters, (as not only fish, but divers insects, and other land-animals do,) that their young cannot be hatched, fed, or nursed up in any other element. It is manifest also, that insects, which lay their eggs on this, and that, and the other agreeable tree or plant, or in flesh, &c. that it is by that means their young are fed and nursed up. And it is little to be doubted also, but that these matrixes may much conduce to the maturation and production of the young. And so in all other the like cases of nidification, of heat or cold, wet or dry, exposed or open, in all probability this is the best method for the animal's good, most salutary and agreeable to its nature, most for its fecundity, and the continuance and increase of its species; to which every species of animals is naturally prompt and inclined.

Thus admirable is the natural sagacity and instinct of the irrational animals in the convenience and method of their habitations. And no less it is in the fabric of them. Their architectonic skill, exerted in the curiosity and dexterity of their works, and exceeding the skill of man to imitate; this, I say, deserves as much or more admiration and praise, than that of the most exquisite artist among men *. For with what inimitable art (*b*) do

(*b*) Of the subtilty of birds in nidification, see *Plin. Nat. Hist.* l. 10. c. 33.

* The amazing skill and artifice, as well as industry, displayed by the beavers in the construction of their habitations, merit

do these poor untaught creatures lay a parcel of rude and ugly sticks and straws, moss and dirt together,

merit in this place a particular account ; and this we shall give in the words of M. Bonnet.

“ A society of beavers seems to be an academy of engineers that proceed on rational plans, which they rectify or modify as they judge necessary, pursuing them with equal constancy and precision : they are all animated by the same spirit, and unite their will and strength for the promoting one common end, which is always the general good of the society. In a word, we must be witnesses of their performances before we can judge them capable of them. A traveller that is ignorant of them, and happens to meet with their habitations, will think he is among a nation of very industrious savages.

“ About the month of June or July the beavers form themselves into a body to the number of two or three hundred. They assemble themselves on the banks of lakes or rivers. It is well known that they are amphibious. It is of particular importance for them to prevent the bad effects resulting from the increase or abatement of the waters, in the midst of which they build their habitations. This they effect as we do by banks and sluices. If they take up their residence on a lake, as the surface of its waters is not subject to much variation, they do not trouble themselves with constructing any embankment, but they never fail to rear one when they settle upon a river. This mole or bank is often a work of immense labour, and it is inconceivable how brutes are able to project, to begin, and complete it. Represent to yourself a river of four score, or an hundred feet in width. Their first business is to break the force of the current. Then they throw up a bank or causeway, the whole breadth of the river of the thickness of ten or twelve feet at its base. Beavers are furnished with no other tools for their operations than four strong incisory teeth, four feet, the two anterior of which have a kind of toes, and a scaly tail shaped like an oval shovel. Yet with such instruments as these they are able to subdue the waters, and challenge our
maçons

gether, and form them into commodious nests? With what curiosity do they line them within,

maçons and carpenters to equal them when armed with their trowel, plummet, and axe. If they find a great tree on the border of the river they gnaw it down at the foot, strip off the branches that they may lay it lengthways, and make it serve as the principal part of the bank. Whilst one part of the beavers are employed about this work, others go in search of small trees, which they cut and lop like stakes, and convey both by land and water to the place appointed for using them: With these stakes they construct piles which they strengthen by interweaving branches of trees betwixt them. Others bring thither a kind of mortar which they have kneaded with their feet. This they distribute in the vacant places between the piles, and afterwards beat it with their tails. As soon as the bank is finished, the grand society divides itself into several particular ones, each of which chooses their quarter where they build for themselves a commodious habitation. This is a kind of hut built on piles, of a round or oval figure. The walls are about two feet thick and very strongly built. The partitions are lined with a kind of straw which the animals lay on with their tails. Each hut has two outlets, one by land the other by water. The largest huts are eight or ten feet in diameter, the smallest four or five: the former are capable of containing sixteen, eighteen, or twenty beavers, the latter six or eight. Their common food is the bark of some tender trees, as the alder, poplar, or willow. Against the winter they collect a sufficient quantity of it in magazines under water. Each cottage has its magazine. The most considerable towns of the beavers consist of twenty or twenty-five lodgments, though such are but rare. The most common have only twelve. Each republic has its peculiar district, and admits of no accidental guests. When any great inundations damage the edifices of the beavers, all the societies or families unite together to make the necessary repairs."—*Contemplation de la Nature*, part xi. ch. 26.

EDITOR.

wind

wind and place every hair, feather, or lock of wool, to guard the tender bodies of themselves, and their young, and to keep them warm? and with what art and craft do many of them thatch over, and coat their nests without, to mislead and deceive the eye of spectators, as well as to guard and fence against the injuries of weather (i)? with
what

(i) Among many instances that might be given of this subtilty of birds, and other creatures, that of the *long-tailed tit-mouse* deserves observation, who with great art builds her nest with mosses, hair, and the webs of spiders, cast out from them when they take their flight, (see *book viii. chap. 4. note (e).*) with which the other materials are strongly tied together. Having neatly built, and covered her nest with these materials without, she thatcheth it on the top with the *muscus arboreus ramosus*,—"the woody, branched moss,"—or like such broad, whitish moss, to keep out rain, and to dodge the spectator's eye; and within she lineth it with a great number of soft feathers; so many, that I confess I could not but admire how so small a room could hold them, especially that they could be laid so close and handsomely together, to afford sufficient room for a bird with so long a tail, and so numerous an issue as this bird commonly hath, which Mr. Ray saith, (*Synops. Method. Avium*, p. 74.) *Ova inter omnes aviculas numerosissima ponit.*—"Of all birds she lays the greatest number of eggs." See more of the nest of this bird, from *Aldrovand. in Willugh. Ornith.* p. 243. *

* The *motacilla sutoria*, or taylor-bird, is a native of the East Indies. The manner in which it constructs its nest, so as to secure it from danger from voracious animals, is most remarkable. It is not fixed to a twig of a tree but to a single leaf. This small creature picks up a dead leaf, which it sews to

what prodigious subtilty do some foreign birds (*k*), not only plait and weave the fibrous parts of vegetables together, and curiously tunnel them, and commodiously form them into nests, but also artificially suspend them on the tender twigs of trees, to keep them out of the reach of rapacious animals?

And so for *insects*, those little, weak, those tender creatures; yet what admirable artists are they in this business of nidification! with what great diligence doth the little *bee* gather its combs from various trees (*l*) and flowers, the *wasps* from

(*k*) The nest of the *guira tangeima*, the *icterus minor*, and the *jupujuba*, or whatever other name the *American hang-nests* may be called by, are of this kind. Of which see *Willughby's Ornith.* lib. 2. chap. 5. sect. 12, 13. Also *Dr. Grew's Museum Reg. Soc.* part. 1. sect. 4. chap. 4. These nests I have divers times seen, particularly in great perfection in our *R. S.* repository, and in the noble and well-furnished *museum* of my often-commended friend *Sir Hans Sloane*; and at the same time I could not but admire at the neat mechanism of them, and the sagacity of the bird, in hanging them on the twigs of trees, to secure their eggs and young from the *apes*. See Plate E, fig. 6.

(*l*) I mention trees, because I have seen *bees* gather the gum of fir-trees, which at the same time gave me the pleasure of seeing their way of loading their thighs therewith, performed with great art and dexterity.

the side of a living one, making use of its bill for a needle, and some slender grassy fibres for thread. It lines its nest, thus formed, with fine feathers or gossamer. The length of this bird is but three inches, and its weight only $\frac{3}{16}$ of an ounce. So that the leaf and its stalk is sufficiently strong to support the animal with its nest and young! See Plate F, fig. 6.

EDITOR.
solid

F

Fig. 1



Fig. 2

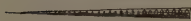


Fig. 3



Fig. 4



Fig. 5

Fig. 7

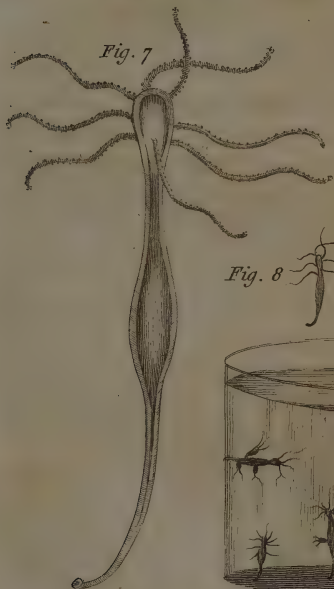


Fig. 8



Fig. 9

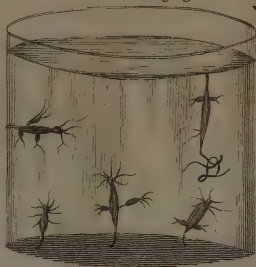


Fig. 6



Fig. 10



Fig. 1. The Opossum who has a bag in the belly for concealing her young.
 Fig. 2. 3. 4. 5. The hair of a mouse. Fig. 6 The motucilla sutoria, or Taylor bird
 which forms its nest by sewing two leaves together. Fig. 7 The common species of
 Polype magnified. 8 The same animal of its natural size. 9 Polypes in various
 attitudes, one of them hooking to it a small worm. The young polypes are seen
 sticking to the body of the parent animal. Fig. 10 The Cluster polype or vorticella

solid (*m*) timber! and with what prodigious geometrical subtilty do those little animals work their deep hexagonal cells*, the only proper figure that the

(*m*) *Wasps*, at their first coming, may be observed to frequent posts, boards, and other wood that is dry and sound; but never any that is rotten. These they may be heard to scrape and gnaw; and what they so gnaw off, they heap close together between their chin and fore-legs, until they have gotten enough for a burden, which they then carry away in their mouths, to make their cells with.

* The following observations of that most able and learned philosopher Dr. Reid, are so apposite to the subject of which our Author here treats, that our reader will easily excuse the length of the quotation.

“Every manufacturing art among men was invented by some man, improved by others, and brought to perfection by time and experience. Men learn to work in it by long practice, which produces a habit. The arts of men vary in every age and in every nation, and are found only in those men who have been taught them. The manufactures of animals differ from those of men in many striking particulars. No animal of the species can claim the invention; no animal ever introduced any new improvement, or any variation from the former practice, every one of the species has equal skill from the beginning, without teaching, without experience, and without habit; every one has its art by a kind of inspiration. I do not mean that it is inspired with the *principles* or *rules* of the art, but with the ability of *working* in it to perfection, without any knowledge of its principles, rules, or end. The work of every animal is indeed like the works of Nature, perfect in its kind, and can bear the most critical examination of the mechanic or the mathematician, of which a honey-comb is a striking instance.” The Doctor then takes notice of the observation of

the best mathematician could chuse for such a combination of houses (n)! with what accuracy do

(n) Circular cells would have been the most capacious; but this would by no means have been a convenient figure, by reason much of the room would have been taken up by vacancies between the circles; therefore, it was necessary to make use of some of the rectilinear figures. Among which only three could be of use; of which *Pappus Alexandrin.* thus discourseth: *Cum igitur tres figuræ sunt, quæ per seipsas locum circa idem punctum consistentem replere possunt, triangulum scil. quadratam & hexagonum, apes illam quæ ex pluribus angulis constat sapienter delegerunt, utpote suspicantes eam plus mellis capere quam utram vis reliquarum. At apes quidem illud tantum quod ipsis utile est cognoscunt, viz. hexagonum quadrato & triangulo esse majus & plus mellis capere posse nimirum æquali materiâ in constructionem uniuscujusque consumptâ. Nos verò qui plus sapientiæ quam apes habere profite-mur, aliquid etiam magis insigne investigabimus.*—“Now as there are three sorts of figures into which a space may be divided without any interstices between the divisions, viz. the triangle, the square, and the hexagon, the bees have wisely chosen that which consists of the most angles, as knowing it would contain the greatest quantity of honey. But the knowledge of the bees is limited to what is useful for themselves; they know, for example, that a hexagon will contain more honey than a triangle, an equal portion of materials being employed in its construction. But we who are endowed with more wisdom than the bees, will make discoveries proportionably greater.”—*Collect. Math.* l. 5.

Pappus, that the hexagonal form of the cells is best fitted both for convenience and strength. “Bees,” says he, “as if they knew this, make their cells regular hexagons. As the combs have cells on both sides, the cells may either be exactly opposite, having partition against partition, or the bottom of a cell may rest upon the partitions between the cells on the other side,

do other insects perforate the earth (*o*), wood, yea stone itself (*p*)! for which service, the complete apparatus

(*o*) See before note (*c*).

(*p*) See chap. II. note (*x*).

side, which will serve as a buttress to strengthen it. The last way is the best for strength; accordingly the bottom of each cell rests against the point where three partitions meet on the other side, which gives it all the strength possible. The bottom of a cell may either be one plane, perpendicular to the side partitions, or it may be composed of several planes meeting in a solid angle in the middle point. It is only in one of these two ways that all the cells can be similar without losing room. And for the same intention the planes of which the bottom is composed, if there be more than one, must be three in number, and neither more nor fewer. It has been demonstrated, that by making the bottoms of the cells to consist of three planes meeting in a point, there is a saving of material and labour no way inconsiderable. The bees, as if acquainted with these principles of solid geometry, follow them most accurately; the bottom of each cell being composed of three planes which make obtuse angles with the side partitions, and with one another, and meet in a point in the middle of the bottom; the three angles of this bottom being supported by three partitions on the other side of the comb, and the point of it by the common intersection of these three partitions. One instance more of the mathematical skill displayed in the structure of a honeycomb deserves to be mentioned. It is a curious mathematical problem *at what precise angle* the three planes which compose the bottom of a cell ought to meet, in order to make the greatest possible saving of labour. This is one of those problems belonging to the higher parts of mathematics, which are called problems of *maxima* and *minima*. The celebrated Mac-laurin resolved it by a fluxionary calculation, which is to be found in the Transactions of the Royal Society of London, and

determined

apparatus of their mouths (*q*) and feet (*r*) deserves particular observation, as hath been, and will

(*q*) See *chap. II. note (y)*.

(*r*) Among many examples, the legs and feet of the *mole-cricket* (*gryllotalpa*) are very remarkable. The fore-legs are very brawny and strong; and the feet armed each with four flat strong claws, together with a small lamina, with two larger claws, and a third with two little claws; which lamina is jointed to the bottom of the foot, to be extended to make the foot wider, or withdrawn within the foot. These feet are placed to scratch somewhat sideways, as well as downward, after the manner of *moles* feet; and they are very like them also in figure.

Somewhat of this nature *Swammerdam* observes of the worms of the *Ephemeron*. To this purpose [to dig their cells] *the wise Creator hath furnished them* (saith he) *with fit members. For, besides that their two fore-legs are formed somewhat like those of the ordinary moles or gryllotalpa, he hath also furnished them with two toothy cheeks, somewhat like the sheers of lobsters, which serve them more readily to bore the clay.* *Swammerdam's Ephem. Vit. published by Dr. Tyson, chap. 3.*

determined precisely the angle required. Upon the most exact mensuration which the subject could admit, he afterwards found, that it is the very angle in which the three planes in the bottom of the cell of a honey-comb actually do meet. Shall we ask here, Who taught the bees the properties of solids, and to resolve problems of *maxima* and *minima*? If a honey-comb were a work of human art, every man of common sense would conclude, without hesitation, that he who invented the construction must have understood the principles on which it was constructed. We need not say that bees know none of these things. They work most geometrically without any knowledge of geometry; somewhat like a child, who, by turning the handle of an organ, makes good music without any knowledge

will be hereafter observed. And further yet, with what care and neatness do most of those little sagacious animals line those their houses within, and seal them up, and fence them without (s)! how artificially will others fold up the leaves of trees and plants (t); others house themselves in sticks and straws; others glue light and floating bodies together (u), and by that artifice make themselves

(s) See the before-cited note (c).

(t) They are for the most part, some of the *phalena*-tribe, which inhabit the tunnelled, convolved leaves, that we meet with on vegetables in the spring and summer. And it is a somewhat wonderful artifice, how so small and weak a creature as one of those newly hatched maggots, (for doubtless it is they, not the parent animal, because she emits no web, nor hath any tectrine art,) can be able to convolve the stubborn leaf, and then bind it in that neat round form, with the thread or web it weaves from its own body; with which it commonly lines the convolved leaf, and stops up the two ends, to prevent its own falling out, and earwigs and other noxious animals getting in.

(u) The several sorts of *phryganea*, or *caddis*, in their *nympha* or *maggot-state*, thus house themselves; one sort in straws, called from thence *straw-worms*; others in two or more sticks, laid parallel to our another, creeping at the bottom of brooks; others with a small bundle of pieces of rushes, duck-weed, sticks, &c. glued together, wherewith they float

on

knowledge of music. The art is not in the child, but in him who made the organ. In like manner, when a bee makes its combs so geometrically, the geometry is not in the bee, but in that great Geometrician who made the bee, and made all things in number, weight, and measure.”

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themselves floating houses in the waters, to transport themselves at pleasure after their food, or other necessary occasions of life! and for a close, let us take the scriptural instance of the *spider*, *Prov. xxx. 28.* which is one of the four little things, which, *v. 24.* *Agur* says, is *exceeding wise: the spider taketh hold with her hands, and is in kings palaces (w).* I will not dispute the truth of our

on the top, and can row themselves therein about the waters, with the help of their feet: both these are called *cob-bait*. Divers other sorts there are, which the reader may see a summary of, from Mr. *Willughby*, in *Raii Method. Insect.* p. 12. together with a good, though very brief description of the *papilionaceous* fly, that comes from the *cob-bait* cadew. It is a notable architectonic faculty, which all the variety of these animals have, to gather such bodies as are fittest for their purpose, and then to glue them together; some to be heavier than water, that the animal may remain at the bottom, where its food is (for which purpose they use stones, together with sticks, rushes, &c.); and some to be lighter than water, to float on the top, and gather its food from thence. These little houses look coarse, and shew no great artifice outwardly; but are well tunnelled, and made within with a hard tough paste; into which the hinder part of the maggot is so fixed, that it can draw its cell after it any where, without danger of leaving it behind; as also thrust its body out, to reach what it wanteth, or withdraw it into its cell, to guard it against harms. See Plate O, *fig. 1, 2, 3, 4, 5, 6, 7, 8.*

(w) Having mentioned the *spider*, I shall take this occasion, (although it be out of the way) to give an instance of the poison of some of them. *Scaliger, Exerc. 186.* relates, that in Gascony, his country, there are spiders of that virulency, that if a man treads upon them, to crush them, their poison will pass through the very soles of his shoe. *Boyl. Subtil. of Effluv. c. 4.*

Mr.



1.2.3.4.5.6. Different Phryganea or Cadews, found upon the gravelly bottom of shallow Brooks. 7.8. The papilionaceous Flie which issues from them.

our *English* translation of this text, but supposing the animal mentioned to be that which is meant ;

it

Mr. *Leeuwenhoek* put a *frog* and a *spider* together into a glass, and having made the *spider* sting the *frog* divers times, the *frog* died in about an hour's time. *Phil. Transf.* No. 272.

In the same *Transfation*, is a curious account of the manner how *spiders* lay, and guard their eggs, viz. they emit them not out of the hindermost part of the body, but under the upper part of her belly near the hind legs, &c. Also there is an account of the parts from which they emit their webs, and divers other things worth observation, with cuts illustrating the whole.

But in *Phil. Transf.* No. 22. Dr. *Nath. Fairfax*, from *S. Redi*, and his own observations, thinks *spiders* not venomous ; several persons, as well as birds, swallowing them without hurt : which I myself have known in a person of learning, who was advised to take them medicinally at first, and would at any time swallow them, affirming them to be sweet, and well tasted : and not only innocuous, but they are very salutiferous too, in some of the most stubborn diseases, if the pleasant story, in *Mouffet* be true ; of a rich *London* matron, cured of a desperate *tympany*, by a certain debauchee, that hearing of her case, and that she was given over by the doctors, went to her, pretending to be a physician, and confidently affirming he would cure her ; which she being willing to believe, agrees with him for so much money, one half to be paid down, the other upon cure. Upon which he gives her a *spider*, promising her cure in three days. Upon which, (not doubting but that he had poisoned her, and fearing he might be called to account for it,) he gets out of town as fast as he could. But instead of being poisoned, she soon recovered. After some months the quack gets privately to town, when he thought the bustle might be over ; and enquiring how his patient did, was informed of her cure ; and thereupon visiting her, and making

an

it is manifest, that the art of that species of creatures, in spinning their various webs, and the furniture their bodies afford to that purpose, are an excellent instinct, and provision of Nature, setting forth its glorious Author.

And now from this short and transient view of the architectonic faculty of animals, especially the irrationals; we may easily perceive some superior and wise Being was certainly concerned in their creation or original. For, how is it possible that an irrational creature should, with ordinary and coarse, or indeed any materials, be ever able to perform such works, as exceed even the imitation of a rational creature? how could the bodies of many of them (particularly the last mentioned) be furnished with architectivè materials? how could they ever discover them to be in their bodies, or know what use to make of them? We must therefore necessarily conclude, that the irrationals either have reason and judgment, not only glimmerings thereof, but some of its superior acts, as wisdom and foresight, discretion, art, and care; or else, that they are only passive in the case, and act by instinct, or by the reason of some superior Being imprinted in their nature, or some way or other (be it how it will) congenial with them. That

an excuse for his absence, he received his pay with great applause and thanks. *Mouff. Insect. l. 2. c. 15.*

Having said so much of *spiders*, I might here add their flight: but of this see *book viii. chap. 4. note (e).*

they

they are rational, or excel man in art and wisdom, none surely will be so foolish as to say: and therefore we must conclude, that those excellent ends they pursue, and that admirable art they exert, is none of their own, but owing to that infinitely wise and excellent Being, of whom it may be said, with reference to the irrational, as well as rational creature, as it is, *Prov. ii. 6. The Lord giveth wisdom; out of his mouth cometh knowledge and understanding.*

C H A P. XIV.

Of Animals Self-preservation.

HAVING thus considered the food, cloathing, and houses of animals; let us in this Chapter take a glance of another excellent provision the wise Creator hath made for the good of the animal world; and that is, the methods which all animals naturally take for their *self-preservation* and *safety*. And here it is remarkable, (as in the cases before,) that man, who is endowed with reason, is born without armature, and is destitute of many powers, which irrational creatures have in a much higher degree than he, by reason he can make himself arms to defend himself, can contrive methods for his own guard and safety, can many ways annoy his enemy, and stave off the harms of noxious creatures.

But for others, who are destitute of this super-eminent faculty; they are some way or other provided with sufficient guard (a), proportionate to their

(a) *Callent in hoc cuncta animalia, sciuntque non sua modo comoda, verum & hostium adversa; nōrunt sua tela, nōrunt occasiones, partesque dissidentium imbelles. In ventre mollis est tenuisque cutis crocodilo: ideoque se, ut territi, mergent delphini, subeuntesque alvum illa secant spinā.*—“ In this all animals are eminently sagacious: they know not only their own advantages, but the
weak

their place of abode, the dangers they are like to incur there (*b*); and in a word, to their greatest occasions,

weak parts of their enemies; they are skilful in the use of their own weapons, can seize their opportunities, and attack their foe on his defenceless quarter. The crocodile has a soft and thin skin under the belly. The dolphin plunges under him as if from terror, but rips him up in that weak quarter with his sharp snout.”—*Plin. Nat. Hist.* l. 8. c. 25.

(*b*) *Omnibus aptum est corpus animæ moribus & facultatibus: equo fortibus unguis & jubæ est ornatum (etenim velox & superbum & generosum est animal). Leoni autem, utpote animoso & feroci, dentibus & unguibus validum. Ita autem & tauro & apro; illi enim cornua, huic exerti dentes.—Cervo autem & lepore (timida enim sunt animalia) velox corpus, sed inerme. Timidis enim velocitas, arma audacibus conveniebant.—Homini autem (sapiens enim est—) manus dedit, instrumentum ad omnes artes necessarium, paci non minus quàm bello idoneum. Non igitur indiguit cornu sibi innato cum meliora cornibus arma manibus, quandocunque volet, possit accipere: etenim ensis & hasta majora sunt arma, & ad incidendum promptiora.—Neque cornu, neque ungulæ quicquam nisi cominus agere possunt; hominum verò arma eminùs juxtà ac cominus agunt: telum quidem & sagitta magis quàm cornua.—Non igitur est nudus, neque inermis.—Sed ipsi est thorax ferreus, quandocunque libet, omnibus coriis difficilius sauciato organum.—Nec thorax solùm sed & domus, & murus, & turris, &c.—“The body of every animal is suited to its habits and dispositions. The horse, a swift, high met-tled, and generous animal, is furnished with strong hoofs and a flowing mane. The bold and ferocious lion has his strong teeth and claws. The bull has his horns, the boar his protruded tusks.—The timid stag and hare have no other defence than in their speed of foot; for speed is suitable to the timorous as arms to the bold.—To man endowed with wisdom, Nature has given hands, that wonderful instrument, adapted to all arts, serviceable alike in peace as in war. To him the horns of the bull would be superfluous, for his hands can frame and wield a more powerful instrument than horns, the sword and*

occasions, and need of security *. Accordingly, some are sufficiently guarded against all common dangers, by their natural cloathing, by their armature of shells †, or such like hard, and impreg-

and spear; arms that are equally powerful in close engagement and at a distance; whereas horns and hoofs can be used only in close fight. Man, therefore, cannot be said to be naked or unarmed; he can clothe himself in iron coats of mail, more impenetrable than the toughest hide; nay, he assumes an armour of stone; for houses, walls, and towers are his defence. *Galen. de Uf. Part. 1. 1. c. 2.*

* Many of the domestic animals seem to rely solely upon man for their protection, but, as an eloquent writer (Goldsmith) well remarks, we are not to impute to Nature the formation of any species of animals destitute of means to defend itself against its enemies. The sheep is apparently of all animals the most defenceless, but the *moufflon*, which is the sheep in its savage state, is a bold fleet creature, able to escape from the greater animals by its swiftness, or to oppose the smaller kinds with the arms it has received from Nature. It is by human art alone, that the sheep is become the tardy defenceless creature we find it. It is protected from danger by man for his own ends, and its food is supplied to it in abundance. But in a savage state, constantly practising the arts of defence and of escape, this animal at once resumes its life and its native independence, together with its swiftness and the slender agility of its form. EDITOR.

† The armadillo is covered with a thick shell of different pieces joined like the tail of a lobster, and of so hard a consistence, that it is proof against the attacks of all other animals. It is generally found in rocky places, and when pursued by hunters for the sake of its flesh, which is very delicious, it rolls itself up like a ball, and throws itself down a precipice, tumbling from rock to rock, without the smallest injury.

nable covering of their body (*c*). Others destitute of this guard are armed, some with horns (*d*), some with sharp quills and prickles (*e*), some with claws, some

(*c*) Shells deserve a place in this survey, upon the account of their great variety; the curious and uncouth make of some, and the beautiful colours, and pretty ornaments of others; but it would be endless to descend to particulars. Omitting others, I shall therefore only take notice of the *tortoise-shell*, by reason a great deal of dexterity appears, even in the simplicity of that animal's skeleton. For, besides that the shell is a stout guard to the body, and affords a safe retreat to the head, legs, and tail, which it withdraws within the shell upon any danger; besides this, I say, the shell supplieth the place of all the bones in the body, except those of the extreme parts, the head and neck, and the four legs and tail. So that at first sight, it is somewhat surprising to see a complete skeleton consisting of so small a number of bones, and they abundantly sufficient for the creature's use.

(*d*) *Dente timentur aprī: defendunt cornua tauros:*

Imbelles damæ quid nisi præda sumus?

“The boar his tusks, the bull his horns defend,

“Th’ unarm’d and inoffensive doe must bleed.”

Martial. *l.* 13. Epigr. 94.

(*e*) The *hedgehog*, being an helpless, slow, and patient animal, is accordingly guarded with prickles, and a power of rolling itself up in them. *Clavis terebrari sibi pedes, & discindi viscera patientissimè ferebat, omnes cultri ictus sine gemitu plusquam Spartanâ nobilitate concoquens.*—“It patiently endured its feet to be bored through with nails, and its bowels to be cut open, suffering all the wounds of the knife without a groan, and with more than Spartan courage.”—*Borrichius in Blas. de Echino. Panniculum carnosum amplexabatur musculus penè circularis, admirandæ fabricæ, lacinias suas ad pedes, caudam, caput, variè exporrigens, cujus ministerio echinus se ad arbitrium in orbem contrahit.*—“A muscle almost circular, and of admirable texture, surrounds and embraces a fleshy tunicle, the edges of which extend

some with stings (*f*); some can shift and change their colours (*g*); some can make their escape by the

extend to the feet, the tail, and the head; by means of which the hedgehog gathers itself into a globular form at pleasure."

Æt. Dan. in Basio.

Ille licet digitos testudine pungat acutâ,

Cortice deposito mollis echinus erit.

"Though with his prickly coat he scares the touch,

"Yet underneath he hides a velvet skin."

Mart. l. 13. Epigr. 86.

(*f*) The *sting* of a *wasp*, or *bee*, &c. is so pretty a piece of work, that it is worth taking notice of, so far as I have not found others to have spoken of it. Others have observed the sting to be an hollow tube, with a bag of sharp penetrating juices, (its poison,) joined to the end of it, within the body of the *wasp*, which is, in stinging, injected into the flesh through the tube. But there are, besides this, two small sharp bearded spears, lying within this tube or sting, as in a sheath. In a *wasp's* sting, I counted eight beards on the side of each spear, somewhat like the beards of fish-hooks. These spears in the sting, or sheath, lie one with its point a little before that of the other, as is represented in Plate E, *fig. 2*, to be ready (I conceive) to be first darted into the flesh; which being once fixed, by means of its foremost beard, the other then strikes in too, and so they alternately pierce deeper and deeper, their beards taking more and more hold in the flesh; after which the sheath or sting follows, to convey the poison into the wound. Which, that it may pierce the better, it is drawn into a point, with a small slit a little below that point, for the two spears to come out at. By means of this curious mechanism in the sting, it is, that the sting when out of the body, and parted from it, is able to pierce and wound us: and by means of the beards being lodged deep in the flesh, it comes to pass that *bees* leave their stings behind them, when they are disturbed before they have time to withdraw their spears into their scabbard. In Plate E, *fig. 2*, is represented the two spears as they lie in the sting. In *fig. 3*, the two spears are represented when

the help of their wings, and others by the swiftness of their feet; some can screen themselves by diving

when squeezed out of the sting or the scabbard; in which latter, *fig. A, c, b*, is the sting, *c, d*, and *b, e*, the two bearded spears thrust out*.

(g) The *camelion* is sufficiently famed on this account. Besides which, *Pliny* tells us of a beast as big as an *ox*, called the *tarandus*, that when he pleaseth, assumes the colour of an *ass*, and *colorem omnium fruticum, arborum, florum, locorumque reddit, in quibus latet metuens, ideoque rarò capitur*.—"He reflects the colours of all shrubs, trees, flowers, and of the place where he lies, and hiding himself from fear, he is on that account very rarely taken."—*Plin. l. 8. c. 34.*

How true this is, there may be some reason to doubt; but if any truth be in the story, it may be from the animal's choosing such company, or places, as are agreeable to its colour: as I have seen in divers *caterpillars*, and other insects, who I believe were not able to change their colour from one hue to another; yet I have constantly observed, do fix themselves to such things as are of the same colour; by which means they escape the spectator's eye. Thus the *caterpillar* that feeds on *elder*, I have more than once seen so cunningly adhering to the small branches of the same colour, that it might be easily mistaken for a small stick, even by a careful view. So a large green *caterpillar*, that feeds on *buckthorn*, and divers others.

To

* A more particular delineation of the sting of the bee, and its appendages, will be found in Plate E, figure 4.; *b* is the poison bag; *i* the tube which secretes the poison; *m m m m* are four cartilages, with the aid of which, and the four muscles *o o o o*, the bee moves its sting different ways; *p p* are two muscles which draw the two shanks of the sting into their bodies.

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diving in the waters, others by tinging and disordering the waters (*b*), can make their escape; and some can guard their bodies, even in the very flames, by the ejection of the juice of their bodies;

To which I may add the prodigious sagacity of the *ichneumon flies*, that make the *kermes* (for of that tribe all the *kermes* I ever saw was); how artificially they not only inclose their eggs within that gummy skin or shell; but also so well humour the colour of the wood they adhere to, by various streaks and colours, that it is not easy to distinguish them from the wood itself.

(*b*) *Contra metum & vim, suis se armis quæque defendit. Cornibus tauri, apri dentibus, morsu leones, aliæ fugâ se, aliæ occultatione tutantur: atramenti effusione sepia, torpore torpedines. Multæ etiam insectantes odoris intolerabili fæditate depellunt**.—“Each has its arms of defence against danger and violence. The bull has his horns, the boar his tusks, the lion his fangs; some save themselves by flight, and others by concealment. The scuttle-fish defends itself by an effusion of ink, and the *torpedo* by numbing those who touch it. Many animals too drive off their persecutors by the intolerable stench they throw out.”—*Cic. de Nat. Deor. l. 2. c. 50.*

* We perceive from this quotation, that the torpedo, or numbing fish, was known to the ancients. But another species of fish has lately been discovered, whose properties, though analogous to those of the torpedo, are still more surprising. The *gymnotus electricus*, or torporific eel of Surinam, is a species of lamprey about three feet in length, and twelve inches in circumference. The head is equal in size to the largest part of the body; the mouth is large and without teeth. This animal, when touched, communicates a perfect electrical shock. When caught by a hook, the shock is felt by the person who holds the line. When touched with an iron rod, the same sensation is felt, and ten or a dozen persons holding each other's hands,

dies (*i*); and some by their accurate smell, sight, or hearing, can foresee dangers (*k*); others, by their natural craft, can prevent or escape them (*l*); others by their uncouth noise (*m*); by the horrid aspect, and ugly gesticulations of their body (*n*);
and

(*i*) A knight, called *Corvini*, at *Rome*, cast a *salamander* into the fire, which presently swelled, and then vomited store of thick slimy matter, which put out the coals; to which the *salamander* presently retired, putting them out again in the same manner, as soon as they re-kindled, and by this means saved itself from the force of the fire for the space of two hours: after which it lived nine months. Vide *Philos. Transf.* No. 21. in *Lowth.-Abridg.* vol. ii. p. 816.

(*k*) *Pliny* gives an instance in each, l. 10. c. 69. *Aquilæ clariùs cernunt [quàm homines]; vultures sagaciùs odorantur: liquidiùs audiunt talpæ obrutæ terrâ, tam denso atque surdo naturæ elemento.*—"Eagles see more clearly than men; vultures have more sagacity of smell; moles hear most acutely though buried in the earth, that dense and obtuse element."

(*l*) The *doublings* of the *hare*, before she goes to form, thereby to dodge and deceive the *dogs*, although a vulgar observation, is a notable instinct for an animal, less famed for cunning than the *fox*, and some others.

(*m*) It is natural for many quadrupeds, birds, and serpents, not only to put on a torvous angry aspect when in danger; but also to snarl, hiss, or by some other noise deter their adversary.

(*n*) The *ixnx*, or *wryneck*, although a bird of very beautiful feathers, and consequently far enough off from being any way terrible;

hands, are all sensible of the shock at the same instant. When the animal is enraged it communicates a shock to a person who brings his hand within five or six inches, though without touching it. See *Bancroft's Natural History of Guiana*, or an Extract from it in the *Annual Register* for 1769. EDITOR.

and some even by the power of their excrements *, and their stink (o), can annoy their enemy, and secure

terrible; yet being in danger, hath such odd contortions of its neck, and motions of its head, that I remember have scared me, when I was a boy, from taking their nests, or touching the bird; daring no more to venture my hand into their holes, than if a serpent had lodged in it.

(o) *Bonafus tuetur se calcibus & stercore, quòd ab se quaternis passibus* [trium jugerum longitudine.—*Plin. Nat. Hist. l. 8. c. 15.*] *ejaculatur, quod sæpe comburit adeò ut deglabrentur canes.*—“The bonafus defends itself with its heels and by its excrement, which it throws out to a great distance, and which burns so that the dogs are stripped of their hair by it.”—*Ray’s Synops. Quadr. p. 71.*

Camelus Peruvianus clama dictus neminem offendit, sed miro admodum ingenio se ab illatâ vindicat injuriâ, nimirum vomitu vel cibi, vel humoris in vexantem retrorsum cum impetu ejaculato, ob protensam colli longitudinem.—“The Peruvian camel, called *clava*, is a most

* The Armenian polecat or squash, when pursued or irritated, squirts upon its persecutors an excrementitious liquor of so horrible a smell that neither man nor dog can endure it. “In the year 1749 (says *Kalm*) one of these animals came near the farm where I lived. It was in winter-time and during the night, and the dogs that were upon the watch pursued it for some time, until it discharged against them. Although I was in my bed a good way off, I thought I should have been suffocated; and the cows and oxen themselves, by their lowings, shewed how much they were affected by the stench. Another crept into the cellar, and upon being disturbed by a woman, spread its stench to such a degree, that the woman kept her bed for several days after; and all the bread, meat, and other provisions that were kept there were so infected, that we were obliged to throw them out of doors.”—*Voyage de Kalm.*

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secure themselves: and against some (*p*), the Divine Providence itself hath provided a guard.

By

a most inoffensive animal; but it defends itself with a wonderful ingenuity against injury, by vomiting its food, which it throws behind it with great force upon its persecutor, being furnished with a long extended neck.”—*Id. ib.* p. 146.

Tzquiepatl (Anglicè *squnck* præf. and one that I saw they called a *stonck*,) *cum quis eam insectatur, fundit cum ventris crepitu halitum fetidissimum: quin ipsa tota teterrimum exhalat odorem, & urina stercusque est fetidissimum, atque adeò pestilens, ut nihil sit reperire in nostro orbe, cui in hac re possit comparari: quo fit, ut in periculo constituta, urinam & feces ad 8 plurimumve passuum interval- lum ejiciat, hoc modo se ab omnibus vindicans injuriis, ac vestes inficiens maculis luteis indelebilibus, & nunquam satis perspirante odore: aliàs innoxium animal eduleque, hâc solâ ratione horrendissimum.*—“The *tzquiepatl*, called in English the *skunk* or *stonck*, when it is pursued, throws out a most fetid vapour with a great explosion from its belly. The whole animal, indeed, exhales a most pestiferous odour, and its urine and dung are of so fetid and pestilent a quality, that nothing in our quarter of the world can be compared to it. When it is in danger it throws out its urine and excrement to the distance of above eight paces, thus defending itself against all injury, and infecting the clothes of its pursuers with dirty stains which can never be washed out, and which never lose their smell. It is otherwise a very harmless animal, and may be eaten; but on that account alone it is held in abhorrence.”—*Id. ib.* p. 182.

Si accipiter ardeam in sublimi molestat, stercore immisso in pennas ejus, eas putrescere facit: uti Solinus scribit de bonaso, &c. Ita & lupus urinam spargit in persequentem.—“If a heron flying above is molested by a hawk, he squirts his dung upon the hawk’s feathers, which causes them to rot; as Solinus relates in writing of the *bonaso*, &c. So a wolf throws out its urine upon its persecutors.”—*Ol. Mag. Hist.* l. 19. c. 14.

(*p*) Thus against the *crocodile*, which can catch its prey only before it, not on one side. So the *shark*, of which take

By such shifts and means as these, a sufficient guard is ministered to every species of animals, in its proper respective place; abundantly enough to secure the species from destruction, and to keep up that balance, which I have formerly shewed, is in the world among every, and all the species of animals; but yet not enough to secure individuals from becoming a prey to man, or to other creatures, as their necessities of life require*. To which

my often-commended friend Sir *Hans Sloane's* observation: *It hath this particular to it, with some others of its own tribe; that the mouth is in its under part, so that it must turn the belly upwards to prey. And was it not for that time it is in turning, in which the pursued fishes escape, there would be nothing that could avoid it; for it is very quick in swimming, and hath a vast strength, with the largest swallow of any fish, and is very devouring.* *Sloane's Voyage to Jamaica, p. 23.*

* The instinctive conduct of animals in providing against danger is most remarkable. Though monkeys sleep on trees, a centinel is always appointed, who must not sleep under pain of being torn to pieces. They observe the same precaution when they rob an orchard: a centinel on a high tree is watchful to announce the very first appearance of an enemy. *Buffon*, in treating of a sort of monkey which he calls *Malbrouk*, says, that they are fond of fruit and of sugar-canes; and that while they are loading themselves, one is placed centinel on a tree, who, upon the approach of a man, cries *Houp, houp, houp!* loudly and distinctly, on which they all take to flight. The marmots in like manner appoint a centinel, who when he sees a man, an eagle, or a dog, alarms the whole colony by a loud whistle. Seals place centinels when they go to sleep on the sea-beach. Among beavers notice is given of the approach of an enemy, by the first who observes him, who lashes the

which purpose, the natural sagacity and craft of the one intrapping (*q*), and captivating, being in some measure equivalent to that of the other in evading, is as excellent a means for the maintain-

(*q*) See *chap. II. note (iii)*.

the water with his tail, which is heard in every habitation. (See note * page 83.) Wild elephants, which always travel in company, are less on their guard in places unfrequented; but when they invade cultivated fields, they march in order, the eldest in front and the next in age closing the rear. The weak are placed in the centre, and the females carry their young on their trunk. They attack in a body; and upon a repulse retire in a body.

The formation of societies among animals is founded entirely on the principle of self-preservation. A single sheep is a most defenceless animal; but when a number are united in a flock, upon any violence being offered, the rams all join their forces, and make a most formidable line of battle. A single rook is no match for a kite; but whenever their enemy appears, all that are within sight join in attacking him. The wild swine unite in a body against the wolf and always defeat him. The wild dogs of Congo and Angola hunt in packs, and wage perpetual war against other wild beasts. The final cause of bees uniting in society is a little more complicated, but all reducible to the principle of self-preservation. The stores which they accumulate are a tempting prey to many animals of much superior strength to themselves, against whose attacks a single bee could offer no adequate resistance. The construction of their cells, and the various occupations in which they are engaged, are better performed by the division of labour among the whole colony than if each was to do every thing for himself. The heat produced from the multitude of bees assembled together is, perhaps, necessary both to keep their food in a proper fluid state, and to bring their young to maturity.

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ing the one, as preserving the other; and if well considered, argues the contrivance of the infinitely wise Creator and Preserver of the world *.

* The following observations from an excellent work of Mr. Professor Reimar of Hamburgh, intitled "Physical and Moral Observations on the Instinct of Animals," are highly deserving of attention.

"1. All the industrious instincts in general tend to the preservation of each animal and its species. 2. The means which each animal has of obtaining its ends are, according to its way of living, the wisest and most dexterous that can possibly be imagined. 3. It is in the wants of animals that the true cause of their industrious instincts lies; hence the most despised and most deformed insects have more numerous and more perfect industrious instincts; so that there is none but what is provided with every instinct necessary to its well-being. 4. No species of animals has useless or superfluous instincts; and none is provided with such as are false or foreign to its species. 5. The instincts of animals are actuated by the external perception of pleasure or pain, or by the internal perception of their nature and situation. 6. The present and future generations will not improve on the instinct of past generations; but, on the other hand, the instincts received from Nature are never altered or lost. 7. Every animal knows, without instruction or example, to exert its instincts. 8. Some of the industrious instincts are exerted only at a particular age, in certain circumstances, and but once in the animal's life. 9. In some we discover the instinct of making a determined use of their organs, even before these organs are actually existing; consequently it is not the possession of these organs that prompts them to make use of them. 10. The weakness of some animals, when young, frustrates their instinct for their preservation; hence the care of nourishing and rearing them devolves entirely on their parents; and this care continues till the animals acquire sufficient strength to exert their own instincts. 11. Animals cannot be inspired with any other

other instincts but those which Nature has implanted in them. Yet by making the well-being or unhappiness of animals depend on certain actions calculated for the use or pleasure of man, these instincts may be repressed, directed, or informed; and they may be taught various habits, provided nothing is required of them that is in violent opposition to their natural instincts. 12. All the habits however, and all the tricks which animals may be taught are entirely useless, or at least superfluous to such as are in a state of nature."

To the fourth observation above noted of Mr. Reimar, viz. "That no species of animals has useless or superfluous instincts," we may add the following remarks of Mr. Locke, and of the learned Cardan, on the seeming imperfections of some animals, in which we shall plainly perceive an equal proof of the Divine Wisdom, with what we discover in the perfections and ornaments of others. "We may," says Mr. Locke, "from the make of an oyster or a cockle conclude, that it has not so many nor so quick senses as a man or several other animals: nor if it had, would it, in that state of incapacity of transferring itself from one place to another, be bettered by them. What good would sight and hearing do to a creature that cannot move itself to or from the object wherein, at a distance, it perceives good or evil? And would not quickness of sensation be an inconvenience to an animal that must be still where chance has once placed it, and there receive the afflux of colder or warmer, clean or foul water, as it happens to come to it?"—"What," says Cardan, "is more obvious and ordinary than a mole? and yet what more palpable argument of the Divine Providence? The members of her body are so exactly fitted to her nature and manner of life; for her dwelling being under the ground where nothing is to be seen, Nature has so obscurely fitted her with eyes, that naturalists can hardly agree whether she have any sight at all or no. But in return, what she is capable of for her defence, and giving warning of danger, she has very eminently conferred upon her, for she is very quick of hearing. And then her short tail and short legs, but broad fore feet armed with sharp claws, we perceive to what purpose they are by her so swiftly working herself under ground, and making her way so fast in the earth, that they

they who behold it cannot but admire it. Her legs are short because she needs to dig no more than will serve the mere thickness of her body; and her fore feet are broad that she may scoop away much earth at a time: and she has little or no tail, because making her way through so thick an element, which will not yield easily, as the air and the water, it had been dangerous to have drawn a long train behind her; for her enemy might fall upon her rear, and drag her out, before she had completed or got full possession of her works." In mentioning these instances, we may remark that a similar wisdom and beneficence may be discovered in all the seeming imperfections of the animal creation.

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CHAP. XV.

Of the Generation of Animals.

THERE remains now only one thing more of the ten things in common to animals, and that is what relates to their generation (*a*), and conservation

(*a*) *Spontaneous generation* is a doctrine so generally exploded, that I shall not undertake the disproof of it. It is so evident, that all animals, yea, vegetables too, owe their production to parent animals and vegetables; that I have often admired at the sloth and prejudices of the ancient philosophers, in so easily taking upon trust the *Aristotelian*, or rather, the *Ægyptian* doctrine of *equivocal generation*; that when they saw *flies*, *frogs*, and *lice*, for instance, to be male and female, and accordingly to ingender, lay eggs, &c. they could ever imagine any of these creatures should be spontaneously produced, especially in so romantic a manner, as in the clouds; as they particularly thought *frogs* were, and that they dropped down in showers of rain. For an answer to this case of *frogs*, I shall refer to a relation of my own, which my late most ingenious, and learned friend, the great Mr. Ray, requested of me, and was pleased to publish in his last edition of his *Wisdom of God manifested*, &c. p. 365.

But some will yet assert the raining of *frogs*; among which the curious Dr. Plot is somewhat of this opinion; telling us of *frogs* found on the leads of the lord Aston's gatehouse, at *Tixal* in *Staffordshire*, which he thinks by some such means came there; as also on the bowling-green, frequently after a shower of rain. *Plot's Hist. of Staff.* c. 1. sect. 47.

But we may take a judgment of this, and an hundred such like reports, to be met with in considerable authors, from other the like reports that have been better inquired into. In a scarcity

tion of their species (*b*), by that means. It would not be seemly to advance far in this admirable work
of

city in *Silefia*, a mighty rumour was spread of its raining millet-seed; but the matter being enquired into, it was found to be only the seeds of the *icy-leaved speedwell*, or *small henbit*, growing in the place in great plenty. *Eph. Germ. An. 3. Obs. 40.* So in the *Archipelago*, it was thought ashes were rained, ships being covered therewith at a hundred leagues distance; but in all probability, it was from an eruption of *Vesuvius*, that then happened. About *Warminster* in *Wilts*, it was reported it rained wheat; but a curious observer, *Mr. Cole*, found it to be only *ivy-berries*, blown thither in a considerable quantity by a tempest. In the year 1696, at *Cranstead* near *Wrotham* in *Kent*, a pasture-field was overspread with little young *whitings*, supposed to fall from the clouds, in a tempest of thunder and rain; but doubtless they were brought thither with waters from the sea by the tempest. See the before-commended *Mr. Lowth. Abridg. Phil. Transf. vol. ii. p. 143, 144.*

Neither needeth it seem strange, that *ashes*, *ivy-berries*, small *fishes*, or young *frogs*, (which yet may have some other conveyance,) should be thus transported by tempestuous winds, considering to what distance, and in what quantities, the sea-waters were carried by the great storm, Nov. 26, 1703, of which an ingenious friend sent me these accounts from *Lewes* in *Sussex*, viz. That a physician travelling soon after the storm, to *Titchhurst*, 20 miles from the sea, as he rode along plucked some tops of hedges, and chewing them found them salt: that some grapes, hanging on the vines at *Lewes*, were so too. That *Mr. Williamson*, rector of *Ripe*, found the twigs in his garden salt the Monday after the storm; and others observed the same a week after. That the grass of the downs about *Lewes* was so salt, that the sheep would not feed till hunger compelled them: and that the miller of *Berwick*, (three miles from the sea,) attempting with his man to secure his mill, were so washed with flashes of sea-water, like the breakings of waves against the rocks, that they were almost strangled therewith, and forced to give over their attempt.

of God; neither shall I at all insist upon that of man for the same reason. And as for the irrationals (c), I shall confine myself to these five matters.

I. Their

I called this doctrine of *equivocal generation*, an *Egyptian doctrine*; because probably it had its rise in *Egypt*, to salve the hypothesis of the production of men, and other animals, out of the earth, by the help of the sun's heat. To prove which, the *Egyptians*, (as *Diod. Sicul.* saith,) produce this observation, that about Thebes, when the earth is moistened by the Nile, by the intense heat of the sun, an innumerable number of mice do spring out. From whence he infers, that all kinds of animals might as well at first come likewise out of the earth. And from these the learned bishop *Stillingfleet* thinks other writers, as *Ovid*, *Mela*, *Pliny*, &c. have, without examining its truth, taken up the same hypothesis. *Vide Stillingfleet's Orig. Sacr. Part. 2. book i. chap. 1.*

The before-commended *Dr. Harris*, from the observations of *Dr. Harvey*, *Sr. Malpighi*, *Dr. de Graaf*, and *Mr. Leeuwenhoeck*, infers three things concerning generation as highly probable.

1. That animals are ex animalculo. 2. That the animalcules are originally in semine marium, & non in foeminis. 3. That they can never come forward, or be formed into animals of the respective kind, without the ova in foeminis. His proofs and illustrations, see under the word *generation*, in his *Lex Tech.* vol. ii.

(b) *At certè Natura, si fieri potuisset, maximè optasset suum opificium esse immortale: quod cum per materiam non liceret (nam quod —ex carne est compositum, incorruptibile esse non potest) subsidium quod potuit ipsi ad immortalitatem est fabricata, sapientis cujusdam orbis conditoris exemplo, &c. Nam mirabilem quandam rationem invenit, quomodo in demortui animalis locum, novum aliud sufficiat.* —“ Nature certainly would have wished her work to be immortal, if that had been possible: but as that could not be on account of the materials, (for whatever is composed of flesh must be corruptible,) she devised the best succedaneum to immortality; substituting, by a wonderful process, a new animal into the place of that which dies.” —*Galen de Uf. Part. 1. 14. c. 22.*

(c) *Animantia bruta obstetricibus non indigent in edendo partu, cum inditâ Nature vi umbilicus seipsum occludat.* —“ Brute animals need

I. Their natural sagacity in choosing the fittest places to reposit their eggs and young.

II. The fittest times and seasons they make use of for their generation.

III. The due and stated number of their young.

IV. Their diligence and earnest concern in their breeding up.

V. Their faculty of feeding them, and their art and sagacity exerted therein *.

I. The

need not the aid of a midwife to bring forth their young; for the umbilical cord closes of itself by a certain natural energy.”
Ol. Rudbeck in Blasii Anat. Felis.

* The ingenious author of *Sketches of the History of Man* has remarked, book i. (appendix to Sketch 6.) that the natural history of animals, with respect to pairing and care of their offspring, is susceptible of more elucidation than has been bestowed upon it. He censures Buffon, with justice, for having in many large volumes bestowed scarce a thought on that subject, and observes that the neglect of our own countrymen, Ray and Derham, is still less excusable, considering that to display the conduct of Providence was their sole purpose in writing on natural history. In so far as respects Mr. Derham, this charge is not strictly true to the extent in which it is made, as the perusal of this chapter and of the preceding 11th chapter of the same book, as also chapter 4 of book vii. will evidently shew. The censure on Mr. Ray is likewise unjust in part; for that excellent author has made many striking observations on the extraordinary care manifested by animals in the rearing of their young, and protecting them from danger. (See Ray's *Wisdom of God*, &c. p. 119. eighth edition.) It is true that both these writers have omitted to consider the instinct of *pairing* in some species of animals as affording an argument of the wise and benevolent purposes of Providence;

I. The natural sagacity of irrational animals, in choosing the fittest places to reposit their eggs and young.

an omission which we shall endeavour in some degree to supply, by shortly enumerating the most material of those facts which have fallen under the observation of the author above quoted.

“ The instinct of pairing is bestowed on every species of animals to which it is necessary for rearing their young ; and on no other species. All wild birds pair ; but with a remarkable difference between such as place their nests on trees, and such as place them on the ground. The young of the former being hatched blind, and without feathers, require the nursing care of both parents till they are able to fly. The male feeds his mate on the nest, and cheers her with his song. As soon as the young are hatched, the male betakes himself to a more necessary occupation, the assisting the female to provide food for their offspring. Eagles and some other birds of prey not only pair, but continue in pairs all the year round ; and the same pair procreate year after year. The male and female hunt in company, unless during the season of incubation, when the female is fed by the male. Gregarious birds pair ; in order, probably, to prevent discord in a numerous society confined to a narrow space. This is the case, particularly of pigeons and rooks. The male and female sit on the eggs alternately, and divide the care of feeding their young. Partridges, plovers, pheasants, pea-fowl, grouse, and other kinds that place their nests on the ground, have the instinct of pairing ; but differ from such as build on trees and inaccessible places, in the following particulars, that after the female is impregnated, she completes her task without needing any help from the male. Retiring from him she chooses a safe spot for her nest, where food is at hand, and her young, as soon as they have strength to crawl from the nest, pick up worms, insects, and seeds, for themselves. After this the dam never interferes, unless to lead her flock to proper places for food, and to call them together when danger is impending. Eider ducks pair like other birds that place their nests on the ground, and the female lines her nest with down
plucked

young. Of this I have given larger hints already than I needed to have done, when I spake of the archi-

plucked from her own breast. If the nest be destroyed for the down, which is remarkably warm and elastic, she makes another nest as before. If she be robbed a second time, she makes a third nest; but the male furnishes the down. Pairing birds, excepting those of prey, flock together in February, in order to choose their mates. They soon disperse, and are not seen afterwards but in pairs. Pairing is unknown to quadrupeds that feed on grass. To such it would be useless, as the female gives suck to her young while she herself is feeding. M. Buffon however remarks that the roe-deer are an exception. They pair, though they feed on grass; and have but one litter in the year. Beasts of prey, such as lions, tygers, wolves, pair not. The female is left to shift for herself and for her young; which is a laborious task, and often so unsuccessful as to shorten the life of the parent. Pairing is essential to birds of prey, because incubation leaves the female no sufficient time to hunt for food. Pairing is not necessary to beasts of prey, because their young can bear a long fast. Add another final cause: they would multiply too fast by pairing, and so prove most incommodious to the human race. Among animals that do not pair, males fight desperately about a female. It is not unusual for seven or eight lions to wage bloody war for a single lioness. The same reason that makes pairing necessary for gregarious birds, the prevention of discord in numerous societies, obtains with respect to gregarious quadrupeds, those especially who store up food for winter, and during that season live in common. The beavers with respect to pairing resemble birds that place their nests on the ground. As soon as the young are produced, the males abandon the general stock of food to the females, and live at large; but return frequently to visit them while they are suckling their young. Seals have a singular œconomy. They are polygamous, one male associating with several females. The sea turtle has no occasion to pair, as the female's task is at an end, when she has laid her eggs

architecture (*d*) of animals, intending then to have wholly passed by this business of generation: I shall therefore now only superadd a few other instances, the more to illustrate this matter.

It hath been already shewn, and will hereafter (*e*) farther appear, that the places in which the several species of animals lay up their eggs, and young, are the best for that purpose; waters (*f*)
for

(*d*) Chap. 13.

(*e*) Book viii. chap. 6.

(*f*) The *ephemeron*, as it is an unusual and special instance of the brevity of life; so I take to be a wonderful instance of the special care and providence of God, in the conservation of the species of that animal. For, 1. As an animal, whose life is determined in about five or six hours time, (*viz.* from about six in the evening, till about eleven o'clock at night,) needs no food; so neither doth the *ephemeron* eat, after it is become a fly. 2. As to its generation; in those five hours of its life, it performs that, and all other necessary offices of life: for in the beginning of its life, it sheds its coat; and that being done, and the poor little animal thereby rendered light and agile, it spends the rest of its short time in frisking over the waters, and at the same time the female droppeth her eggs on the waters, and the male his sperm on them to impregnate them. These eggs are spread about by the waters; descend to the bottom by their own gravity; and are hatched by the warmth of the sun, into little worms, which make themselves cases in the clay, and feed on the same without any need of parental care. *Vide Ephem. vita*, translated by Dr. Tyson from Swammerdam. See also book viii. chap. 6. note (*r*).

eggs in the sand. The young are hatched by the heat of the sun; and immediately crawl to the sea. In every other branch of animal oeconomy, concerning the continuance of the species, the hand of Providence is equally conspicuous. EDITOR.

for one; flesh for another; holes in wood (*g*), earth, or stone (*h*), for others; and nests for others; and we shall find, that so ardent is the propensity of all animals, even of the meanest insects, to get a fit place for the propagation of their young; that, as will hereafter appear, there is scarce any thing that escapeth the inquest of those little subtle creatures. But besides all this, there are two or three things more observable, which plainly argue the instinct of some superior rational Being. As,

1. The complete and neat order which many creatures observe in laying up their seed, or eggs, in proper repositories: of which I shall speak in another place (*i*).

2. The suitable apparatus in every creature's body, for the laying-up its eggs, seed, or young, in their proper place. It would be as endless as needless to name all particulars, and therefore an instance or two of the insect-tribe may serve for a specimen in this place, till I come to other particulars. Thus insects, who have neither feet adapted to scratch, nor noses to dig, nor can make artificial nests to lay up their young; yet what abundant amends is there made them, in the power they have either to extend the *abdomen* (*k*), and thereby reach the

(*g*) See *chap. 13. note (c)*, and *book viii. chap. 6.*

(*h*) The *worms* in *chap. 11. note (x)* breed in the holes they gnaw in stone, as is manifest from their eggs found therein.

(*i*) See *book viii. chap. 6. note (q)*.

(*k*) Many, if not most flies, especially those of the *flesh-fly*-kind, have a faculty of extending their *uropigia*, and thereby are enabled to thrust their eggs into convenient holes and receptacles

the commodious places they could not otherwise come at; or else they have some aculeous part or instrument

tacles for their young, in flesh, and whatever else they fly-blow. But none more remarkable than the *horse-fly*, called by *Pennius*, in *Mouffet*, (p. 62.) Σκελιθεῖς, i. e. *curvicauda* or *crook-tail*, and the *whame* or *burrel-fly*, which is vexatious to horses in summer, not by stinging them, but only by their bombylious noise, or tickling them in sticking their nits or eggs on the hair; which they do in a very dexterous manner, by thrusting out their *uropygia*, bending them up, and by gentle, slight touches, sticking the eggs to the hair of the legs, shoulders, and necks, commonly of horses; so that horses which go abroad, and are seldom dressed, are somewhat discoloured by the numerous nits adhering to their hair.

Having mentioned so much of the generation of this insect, although it be a little out of the way, I hope I shall be excused for taking notice of the long-tailed maggot, which is the product of these nits or eggs, called by Dr. *Plot* *eruca glabra* [or rather *eula scabra*, it should be] *caudata aquatico-arborea*, it being found by him in the water of an hollow tree; but I have found it in ditches, saw-pits, holes of water in the highway, and such like places where the waters are most still and foul. This maggot I mention, as being a singular and remarkable work of God, not so much for its being so utterly unlike as it is to its parent *bee-like-fly*, as for the wise provision made for it by its long tail; which is so jointed at certain distances from the body, as that it can be withdrawn, or sheathed, one part within another, to what length the maggot pleaseth, so as to enable it to reach the bottom of very shallow or deeper waters, as it hath occasion, for the gathering of food. At the end of this tapering is a ramification of *fibrillæ*, or small hairs, representing, when spread, a star; with the help of which, spread out on the top of the waters, it is enabled to hang, making, by that means, a small depression or concavity on the surface of the water. In the midst of this star, I imagine the maggot takes in air, there being a perforation, which with a microscope I could perceive to be open, and by the star to be guarded against the incursion of the water.

instrument to terebrate, and make way for their eggs into the root (*l*), trunk (*m*), fruit (*n*), leaves (*o*), and the tender buds of vegetables (*p*),

or

(*l*) The excrescences on the root of *cabbages*, *turnips*, and divers other plants, have always a maggot in them; but what the animal is that thus makes its way to the root under ground, whether *ichneumon*, *phalæna*, *scarab*, or *scolopendra*, I could never discover, being not able to bring them to any thing in boxes.

(*m*) I presume they are only of the *ichneumon-fly-kind* that have their generation in the trunks of vegetables. In *Malpighi de Gallis*, fig. 61. is a good cut of the gouty excrescences, or rather tumours of the *briar-stalk*: from which proceeds a small black *ichneumon-fly*, with red legs; black, smooth jointed *antennæ*; pretty large *thorax*; and short, round belly, of the shape of an heart. It leapeth as a *flea*. The *male* (as in other insects) is lesser than the *female*, and very venereous, in spite of danger, getting upon the *female*, whom they beat and tickle with their breeches and horns, to excite them to a coit. See plate K.

Another example of the generation in the trunks of vegetables shall be from the papers of my often-commended friend Mr. Ray, which are in my hands, and that is, an observation of the ingenious Dr. Nathaniel Wood: I have (said he) lately observed many eggs in the common *rusb*; one sort are little transparent eggs, in shape somewhat like a pear, or retort, lying within the skin, upon, or in the medulla, just against a brownish spot on the outside of the *rusb*; which is apparently the creatrix of the wound made by the fly, when she puts her eggs there. Another kind is much longer, and not so transparent, of a long oval, or rather cylindrical form; six, eight, or more, lie commonly together, across the *rusb*, parallel to each other, like the teeth of a comb, and are as long as the breadth of the *rusb*. Letter from Kilkenny in Ireland, April the 28th, 1697.

(*n*) See book viii. chap. 6. note (*d*).

(*o*) I have in chap. 13. note (*u*), and book viii. chap. 6. note (*e*), (*f*), taken notice of the nidification and generation of some insects, on the leaves of vegetables, and shall therefore, for the illustration

or some other such curious and secure method they are never destitute of. To which we may add,

3. The natural poison (*q*), (or what can I call it?) which many, or most of the creatures, last mentioned, have, to cause the germination of such balls, cases, and other commodious repositories, as are an admirable lodgment to the eggs and young; that particularly assist in the incubation and hatching the young, and then afford them sufficient food and nourishment

Illustration of this place, choose an uncommon example out of the *scarab* kind, (the generation of which tribe hath not been as yet mentioned,) and that is, of a small *scarab* bred in the very tips of *elm-leaves*. These leaves, in summer, may be observed to be, many of them, dry and dead, as also turgid; in which lieth a dirty, whitish, rough maggot. From which proceeds a *beetle* of the smallest kind, of a light, *weefle* colour, that leapeth like a *grasshopper*, although its legs are but short. Its eyes are blackish, *elytra* thin, and prettily furrowed, with many concavities in them; small club-headed *antennæ*, and a long *rostrum* like a *proboscis*.

The same, or much like this, I have met with on tips of *oaken* and *holly-leaves*. How the *scarab* lays its eggs in the leaf, whether by terebrating the leaf, or whether the *maggot*, when hatched, doth it, I could never see. But with great dexterity, it makes its way between the upper and under membranes of the leaf feeding upon the parenchymous part thereof. Its head is slenderer and sharper than most of *maggots*, as if made on purpose for this work; but yet I have often wondered at their artifice, in so nicely separating the membranes of the *elm-leaf*, without breaking them, and endangering their own tumbling out of them, considering how thin, and very tender, the skins of that leaf (particularly) are.

(*p*) See book viii. chap. 6. note (*z*).

(*q*) See book viii. chap. 8. note (*bb*), &c.

nourishment in all their *nympha-state*, in which they need food; and are afterwards commodious houses and beds for them in their *aurelia state*, till they are able to break prison, fly abroad, and shift for themselves. But this shall be taken notice of when I come to treat of insects.

II. As irrational animals choose the fittest place, so also the fittest times and seasons for their generation. Some indeed are indifferent to all times, but others make use of peculiar seasons (*r*). Those, for instance, whose provisions are ready at all seasons, or who are under the tuition of man, produce their young without any great regard to heat or cold, wet or dry, summer or winter*. But others, whose provisions are peculiar, and only to be met with at certain seasons of the year; or who, by their migration, and change of place, are tied up to cer-
tain

(*r*) Πολλὰ δὲ καὶ πρὸς τὰς ἐκτροφὰς τῶν τέκνων σοχαζόμενα, ποιῶνται τὸν συνδυασμὸν ἐν τῇ ἀπαρτιζέσει ὥρα.—“Many animals regulate the time of their copulating to suit the proper season for nourishing and bringing up their young.”—*Arist. Hist. An.* l. 5. c. 8. *ubi plura*.

* Of those quadrupeds that feed on grass, the female is in general delivered of her young early in summer. Gregarious animals who lay up store for the winter, as beavers, generally bring forth in January when they have a plentiful stock of provisions; and in the spring the young animal is strong enough to find its own food. It is remarked to be a law of Nature throughout the animal creation, that the time of gestation is so calculated that the young brood are always able to provide for themselves before another brood comes on. EDITOR.

tain seasons; these (as if endowed with a natural care and foresight of what shall happen) do accordingly lay, hatch, and nurse up their young in the most proper seasons of all the year for their purpose; as in spring or summer, the times of plenty of provisions, the times of warmth for incubation, and the most proper seasons to breed up their young, till they are able to shift for themselves, and can range about for food, and seek places of retreat and safety, by flying long flights as well as their progenitors, and passing into far distant regions, which (when others fail) afford those helpless creatures the necessaries of life.

III. To the special seasons, I may add the peculiar number of young produced by the irrational creatures. Of which I have already taken some notice, when I spake of the balance of animals (*s*). Now, if there was not a great deal more than chance in this matter, even a wise government of the creation, it could never happen that every species of animals should be tied up to a certain rate and proportion of its increase; the most useful would not be the most fruitful, and the most pernicious produce the fewest young, as I have observed it commonly is*. Neither would every species

(*s*) See chap. 10.

* On this subject we have a fine observation of Herodotus:
 “ We may rationally conjecture that Divine Providence has rendered extremely prolific such creatures as are naturally fear-

species produce such a certain rate as it is only able to breed up: but all would be in a confused, huddled state. Instead of which, on the contrary, we find every thing in complete order; the balance of *genera*, species and individuals always proportionate and even; the balance of sexes the same; most creatures tied up to their due stint and number of young, without their own power and choice, and others (particularly of the winged (*t*) kind) producing

(*t*) Mr. Ray alleges good reasons to conclude, That although birds have not an exact power of numbering, yet that they have of distinguishing many from few, and knowing when they come near to a certain number; and that they have it in their power to lay many or few eggs. All which he manifesteth from *hens*, and other domestic fowls, laying many more eggs when they are withdrawn, than when not. Which holds in wild as well as domestic birds, as appears from Dr. Lister's experiment in withdrawing a *swallow's* eggs, which by that means laid nineteen eggs successively before she gave over. *Vide Ray's Wisdom of God, &c. p. 137.*

ful, and serve for food; lest the species should be destroyed by constant consumption; whereas the rapacious and cruel animals are almost barren. The hare, which is the prey of beasts, birds, and men, is a great breeder: a lioness, on the contrary, the strongest and fiercest of beasts, brings forth but once."—It is a most remarkable fact, that the lion, and most of the larger ferocious animals, though we cannot suppose them afraid of man, are by a wonderful œconomy of Providence disposed to shun the habitations of man. At present there is not a wild lion in Europe. When men and cattle are together, a lion always attacks a beast and never a man. The crocodile, a most rapacious animal and of great strength, flies at the sight of a man and hides himself in the water.

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ducing their due number at choice and pleasure; some large numbers, but not more than they can cover, feed and foster; others fewer, but as many as they can well nurse and breed up. Which minds me,

IV. Of the diligence and earnest concern which irrational animals have of the production and breeding up their young. And here I have already taken notice of their *στοργή*, or natural affection, and with what zeal they feed and defend their young. To which may be added these two things:

I. The wonderful instinct of incubation. It is utterly impossible, that ever unthinking, untaught animals should take to that only method of hatching their young, was it not implanted in their nature by the infinitely wise Creator. But so ardent is their desire, so unwearied is their patience when they are engaged in that business, that they will abide their nests for several weeks, deny themselves the pleasures, and even the necessaries of life; some of them even starving themselves almost, rather than hazard their eggs to get food; and others either performing the office by turns (*u*), or else the one kindly seeking out, and carrying food to the

(*u*) *Palumbes incubat femina post meridiana in matutinum, cetero mas. Columbe incubant ambo, interdum mas, noctu femina.*—"The she wood-pigeon sits upon her eggs from noon till midnight or morning, the male then takes his turn. The common pigeons sit, the male in the day-time, and the female in the night." See *supra*, note *, p. 110. and *infra*, note *, p. 155.—*Plin. Nat. Hist.* l. 10. c. 58.

the other (*w*), engaged in the office of incubation. But of these matters in a more proper place (*x*).

2. When the young ones are produced, not only with what care do they feed and nurse them; but with what surprising courage do all or most creatures defend them! It is somewhat strange to see timid creatures (*y*), who at other times are cowardly, to be full of courage and undaunted at that time; to see them furiously and boldly encounter their enemy, instead of flying from him; and expose themselves to every danger, rather than hazard and forsake their young*.

With

(*w*) Of the common *crow*, Mr. Willughby saith, *The females only sit, and that diligently; the males in the mean-time bring them victuals; as Aristotle saith. In most other birds, which pair together, the male and female sit by turns.* Ornithol. lib. 2. sect. 1. cap. 2. sect. 2. And I have observed the female-crows to be much fatter than the males, in the time of incubation; by reason the male, out of his conjugal affection, almost starves himself, to supply the female with plenty.

(*x*) See book vii. chap. 4.

(*y*) *Volucris Natura novam quandam, pullos educandi, rationem excogitavit: ipsis enim præcipuum quendam amorem in ea quæ procrearent, ingeneravit, quo impulsu bellum pro pullis cum ferocibus animalibus, quæ ante declinârunt, intrepidè suscipiunt, victumque ipsis convenientem suppeditant.*—"Nature has wonderfully instructed the birds in the rearing of their young: for she has endowed them with such affection for their offspring, that they encounter with courage the fiercest creatures, whom at other times they shun; and search out for their young the most proper food."—*Galen de Uf. Part. l. 14. c. 4.*

* Animals cure the wounds of their young by licking them. Thus they heal the lacerated umbilical cord. They shew the greatest

With this earnest concern of the irrational animals for their young, we may join in the

Vth

greatest distress when their young are removed. A bitch while they were dissecting her, endeavoured to lick her puppies, and when they were removed, she uttered the most plaintive cries. The following instance of maternal affection in a wild and ferocious animal is well authenticated, as being witnessed by a whole ships crew, *viz.* that of the Carcass frigate, which was sent 20 years ago to make discoveries towards the north pole. It is taken from the Annual Register for 1775. "While the Carcass was locked in the ice, early one morning the man at the mast head gave notice that three bears were making their way very fast over the frozen ocean, and were directing their course towards the ship. They had no doubt been invited by the scent of some blubber of a sea-horse the crew had killed a few days before, which had been set on fire, and was burning on the ice at the time of their approach. They proved to be a she-bear and her two cubs; but the cubs were nearly as large as the dam. They ran eagerly to the fire, and drew out from the flames part of the flesh of the sea-horse that remained unconsumed, and eat it voraciously. The crew from the ship threw great lumps of the flesh of the sea-horse which they had still left upon the ice, which the old bear fetched away singly, laid every lump before her cubs as she brought it, and dividing it gave each a share, reserving but a small portion to herself. As she was fetching away the last piece, they levelled their muskets at the cubs, and shot them both dead; and in her retreat they wounded the dam, but not mortally. It would have drawn tears of pity from any but unfeeling minds, to have marked the affectionate concern expressed by this poor beast in the dying moments of her expiring young. Though she was sorely wounded, and could but just crawl to the place where they lay, she carried the lump of flesh she had fetched away, as she had done others before, tore it in pieces, and laid it down before them; and when she saw that they refused to eat, she laid her paws first upon one, and then upon

Vth and laſt place, Their faculty and ſagacity of feeding them. About which I ſhall take notice of three things.

I. The faculty of ſuckling the young is an excellent proviſion the Creator hath made for thoſe helpſeſ creatures. And here the agreeableneſs and ſuitableneſs of that food to young creatures deſerves particular obſervation; as alſo their delight in it, and deſire and endeavours after it, even as ſoon as born (z), together with the willingneſs of all,

(z) *In iis animantibus quæ lacte aluntur, omnis ſerè cibus matrum lacteſcere incipit : eaque, quæ paulo antè nata ſunt, ſine magiſtro, duce naturâ, mammas appetunt, earumque ubertate ſaturantur. Atque ut intelligamus nihil horum eſſe fortuitum, & hæc omnia eſſe provida, ſolertiſque naturæ, quæ multiplices fœtus procreant, ut ſues, ut canes, his mammarum data eſt multitudo ; quas eaſdem paucas habent cæ beſtiæ, quæ pauca gignunt.*—“ In thoſe animals which are nourished by milk, all the food of the mother turns to milk ; and the young by the guidance of Nature alone, and untaught, ſearch out the dugs of their mother, and thence draw their food till they are ſatiſfied. Moreover, that we may underſtand that nothing of this kind happens by chance, but all ariſes from the wiſe providence of Nature, thoſe animals which produce a number of young at a birth, as ſwine and dogs, are furniſhed with a great number of teats ; and on the contrary thoſe which produce few, have proportionally the fewer teats.”—*Cic. de Nat. Deor. l. 2. c. 51. Conſule quoque Galen de Uſ. Part. l. 14. c. 4. and l. 15. c. 7.*

upon the other, and endeavoured to raiſe them up : all this while it was pitiful to hear her moan. When ſhe found ſhe could not ſtir them, ſhe went off, and when ſhe had got at ſome diſtance, looked back and moaned ; and that not availing her to entice them away, ſhe returned, and ſmelling round them began to lick their

all, even the most savage and fierce animals, to part with it, and to administer it to their young, yea, to teach and institute them in the art of taking it *.

And lastly, to name no more, the curious *apparatus* which is made for this service in the divers species of animals, by a due number of breasts, proportionable to the occasions of each animal, by curious glands in those breasts, to separate that nutritive juice, the milk, by arteries and veins to convey it to them, and proper rivulets and channels to convey it from them, with dugs and nipples, placed in

their wounds. She went off a second time as before; and having crawled a few paces, looked again behind her, and for some time stood moaning. But still her cubs not rising to follow her, she returned to them again, and with signs of inexpressible fondness, went round one, and round the other, pawing them and moaning. Finding at last that they were cold and lifeless, she raised her head towards the ship, and growled a curse upon the murderers, which they returned with a volley of musket-balls. She fell between her cubs, and died licking their wounds." Such is this affecting story; so honourable to the feelings of the brute; so disgraceful to those of humanity. In this conflict of tenderness and affection, with deliberate and wanton cruelty, who can hesitate to declare which of the parties were the savage animals?

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* It is remarkable that Nature has annexed a sense of pleasure to the mother in those acts which are necessary for the support of the young. The action of sucking is not only agreeable as relieving from repletion, but is a positive pleasure to the mother. The warmth which the hen feels from her chickens is no doubt an inducement to cover them with her wings; and perhaps there is something in the smoothness and rotundity of the eggs of birds which gives a pleasurable sensation to the mother, and prompts to incubation.

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in the most convenient part of the body (*aa*) of each animal, to administer it to their young; all these things, I say, do manifestly proclaim the care and wisdom of the great Creator.

2. As

(*aa*) *Animalia solidipeda* & *ruminantia*, vel *cornigera*, inter *femora* *mamas* habent, quorum *fœtus* statim à *partu* *pedibus* *insistunt*, quòd *matres* inter *lactandum* non *decumbant*, ut *equa*, *asina*, &c. *Animalia digitata* & *multipara* in *medio ventre*, scil. *spatio* ab *inguine* ad *pectus* (in *cuniculo* usque ad *jugulum*) *duplicem* *mammarum* *seriem* sortita sunt, quæ omnia *decumbentia* *ubera* *fœtibus* *admovent*, ut *ursa*, *leona*, &c. Si verò hæc in *solo inguine* *mamas* *gererent*, *propria cura* inter *decumbendum* *fœtus* *accessum* ad *mamas* *nonnihil præpedirent*. *Mulieribus* *mammæ* *binæ* *sunt*, ut & *papillæ*, nimirum ut *latus lateri* *conformiter* *respondeat*, & ut *alternatim* *infans* à *latere* in *latus* inter *sugendum* *transferatur*, ne *corpus* *ejus* *uni lateri* *nimis assuescens* *quoquo modo incurvetur*. *Simia*, *homo sylvestris*, &c.—“The solid-footed and ruminating animals, or those which have horns, have their dugs between their hinder-legs; and their young immediately when born stand on their feet, because the mothers while giving suck do not lie down; as for example, the mare, the ass, &c. Those animals that have toes or claws, and produce many young, have a double row of dugs all along the belly, from the parts of generation up to the breast (and in the rabbit up to the throat): all these give suck in a recumbent posture; as the she-bear, the lionsess, &c. If these animals had their dugs only in the hinder part of the belly, their legs, in lying down, would prevent the approach of the young. Women have two breasts and nipples, that the one side may be exactly correspondent to the other, and that the infant may be shifted alternately from side to side, and thus the body may not be bent or crooked by the habit of leaning too much to one side.”—*Blas. Anat. Anim. Part. 1. chap. 6. de Cane ex Whartano*. See here what *Pliny* hath also, *lib. 11. cap. 40*.

In the *elephant*, the nipples are near the breast, by reason the old one is forced to suck herself, and by the help of her trunk conveys the milk into the mouth of her young. Vide *Phil. Transf. No. 336*.

2. As for such animals as do in another manner breed up their young, by finding out food, and putting it into their mouth, the provision made in them for this service, to strike, catch, to pouch, and convey their prey and food to their young (*bb*), is very considerable. And so is also their sagacity in equally distributing it among them, that among many, all shall be duly, equally, and in good order, fed.

3. There

(*bb*) For an exemplification, I might name many animals, particularly birds, whose parts are completely suited to this service. They are characteristics of rapacious birds, to have aduncous bills and talons to hold and tear; and strong brawny thighs to strike and carry their prey; as well as a sharp piercing sight to spy it afar off. *Raii Synops. Method. Av.* p. 1. The pelican also might be here named, for its prodigious bag under its bill and throat, big enough to contain thirty pints. *Id. ib.* p. 122. And, to name no more, the common heron hath its most remarkable parts adapted to this service; long legs for wading; and a long neck answerable thereto to reach its prey; a wide extensive throat to pouch it; long toes, with strong hooked talons, (one of which is remarkably ferrate on the edge,) the better to hold their prey; a long sharp bill to strike their prey, and ferrate towards the point, with sharp hooked beards standing backward, to hold their prey fast when struck; and lastly, large, broad, concave wings (in appearance much too large, heavy, and cumbersome for so small a body, but) of greatest use to enable them to carry the greater load to their nests, at several miles distance; as I have seen them do from several miles beyond me, to a large heronry above three miles distant from me. In which I have seen *plaise*, and other fish, some inches long lying under the high trees in which they build; and the curious and ingenious owner thereof, *D'Acre Barret, esq.* hath seen a large *eel* conveyed by them, notwithstanding the great annoyance it gave them in their flight, by its twisting this way and that way about their bodies.

3. There is yet another instinct remaining, of such animals as can neither administer suck to their young, neither lay them in places affording food, nor can convey and bring them food, but do with their eggs, lay up provisions for their future young. Somewhat of this is reported of some birds (*cc*); but I have myself, with pleasure, frequently seen some of the species of insects to carry ample provisions into their dry and barren cells, where they have sealed them carefully and cautiously up with their eggs, partly, it is like, for incubation-sake, and partly as an easy bed to lodge their young; but chiefly, for future provision for their young, in their *nympha-state*, when they stand in need of food (*dd*) *.

(*cc*) This is reported of the *American ostrich*, mentioned by *Acarette*, in *Philosoph. Transf.* No. 89. Of which see *book vii. chap. 4. note (c)*.

(*dd*) *Hornets, wasps*, and all the kinds of *bees* provide honey; and many of the *pseudosphecæ*, and *ichneumon wasps* and *fliers*, carry *maggots, spiders*, &c. into their nests; of which see above *chap. 13. note (c)*.

* The plan of our excellent Author being to demonstrate the existence and attributes of the Creator from his works, he has, in general, with much propriety drawn his inferences solely from *facts*, and rejected every thing of the nature of *hypothesis* or *theory*: for every hypothesis, however plausible, still leaving room for different suppositions, it would be improper to assume what is in itself but conjectural as a foundation for inductive reasoning. It is probably on this account, that in the preceding chapter *On the Generation of Animals*, the Author has avoided touching at all on those various theories which have

obtained among physiologists respecting the mode of animal production. Whether, for instance, the rudiments of the animal are contained in the male parent, or in the female; whether in both; and if so, what part of the animal structure is attributable to one, and what to the other of the parents; and what is the mode of union of those once separated parts, and of their reciprocal action upon each other. For, as yet, the researches of anatomists and physiologists have arrived at no certainty on this most intricate subject. Of these, however, some have advanced much farther than others. The ingenious Mr. Bonnet, in his *Considerations on Organised Bodies*, and in different parts of his *Contemplation of Nature*, has (I cannot help thinking) reared a theory of generation so well supported, as to leave on the mind a degree of conviction of its truth very near approaching to certainty. This consideration seems to give it a title of admission at least into a note on Mr. Derham's work; and the Editor is well assured he will be easily pardoned for the following quotation, which shews the leading principles on which this theory is founded, and affords a fine example of that mode of reasoning which is best fitted for the discovery of hidden truths.

“ Suppose an accurate naturalist were assured by many repeated observations, that the germ existed in the female before fecundation. Suppose he should strictly demonstrate, that those parts which were thought not to exist, because not perceived, did nevertheless really exist, and already performed their natural functions; what consequences would the philosopher lawfully deduce from these truths? What steps would it be necessary for him to take, in order to clear up the mystery of generation?

“ The first consequence of our philosopher would undoubtedly be this, that as the germ existed before fecundation, it is not produced by fecundation, or, which amounts to the same thing, is not engendered. But it is very certain, that the germ of a bird would never be expanded in the egg without the intervention of the male. I speak of those birds that are best known to us. There must then be something in the germ which prevents it from unfolding of its own accord; as there is somewhat in the fecundating liquor which enables it to do

fo. These are very immediate consequences, and cannot be disputed.

“ The germ then unfolds itself by fecundation. But what is meant by unfolding itself? It is to grow every way, to acquire at the same time more bulk and circumference. The germ, therefore, receives matters foreign to it, which incorporate themselves with its substance; it is nourished, for how should it receive at once a greater degree of bulk and compass were nothing of a strange nature to be added to it? This new consequence is as lawful as the former ones.

“ But nutrition, in a bird, supposes circulation, and this the action of the heart. The heart of the embryo then beats after fecundation; it impels into all the parts the liquid appointed to nourish them, and cause them to unfold. We may discover by the eye its pulsations at the end of the first day of incubation; and it has been proved that they have begun sooner. The heart of the embryo then had not, before fecundation, a degree of force necessary for developement: it must, therefore, have been communicated to it by fecundation. Thus far our philosopher seems to have reasoned well. He must now search for facts which discover the mechanical cause of the motions of the heart. The following are those which claim his attention most.

“ Every muscular fibre contracts itself on the touch of any body whether solid or liquid, and immediately resumes its position. This has been termed *irritability*. Our philosopher does not enquire into the nature of this secret force; he admits it, as the Newtonian admits attraction; I mean, as a certain fact, the cause of which he may always remain ignorant of, and reason with equal justice concerning its consequences. The heart is a real muscle, and one of the most irritable. It continues to move for some time after it has been separated from the breast. But these motions, which we might call spontaneous, cease the very moment the blood quits the cavity. They appear again as soon as new blood, water, or simple air is conveyed into it. Liquors that are a little acid excite them still more. It seems then sufficiently proved, that the cause of the motions of the heart is its *irritability*. Other very singular and very evident facts confirm these, and concur

in establishing the same truth. If then the germ does not unfold itself without the help of fecundation, is it not because the heart has not in it a sufficient share of strength to surmount, by its impulsion, the resistance of the solids? Is not this consequence in the order of natural consequences? The fecundating liquor must then be a sort of *stimulus*.

“ Another fact has just now offered itself to the examination of our philosopher. The organ of the voice of the ass is an instrument that is extremely compounded. It contains parts of a very remarkable structure. That of the voice of the horse is different, and much more simple. The *mule* that proceeds from the union of the ass with the mare, has the organ of its voice constructed, for the most part, like that of its father. If the germ belonged to the female, it would be a horse, and not a mule or an ass that was delineated in miniature in the ovary of the mare. It would answer no end to cavil concerning the existence of eggs in viviparous females: we have seen a foetus that has been perfectly well marked in the ovary; and there are *viviparous* animals that at certain times produce their eggs to open view. The fecundating liquor then acts upon the interior part of the germ, since it modifies, singly, each of its interior parts. It likewise modifies the exterior parts; the ears, buttocks, and tail of the mule, are evident proofs of this. But if the germ pre-existed before fecundation, if it is not engendered; if some parts which seemed not to exist at all did really exist; is it not very probable that the organ of the voice of the mule is likewise not engendered? Will our philosopher violate the rules of sound logic in drawing so natural a consequence? Wherefore the organ of voice in the germ is modified by fecundation; and it is so in an express relation to the father. So likewise are several of the exterior parts in the same relation.

“ But do we conceive how the fecundating liquor can modify the exterior parts of the germ without penetrating into it? We must, therefore, admit that it does penetrate it, although we are not acquainted with the manner of it. It must also be admitted, that it incorporates itself, at least, with the parts it modifies; for these parts are nourished, grow, and unfold themselves in a more or less direct relation to the male; and the male has only furnished a liquor.

“This liquor then itself has secret relations with different parts of the male, since it traces the image of them in the corresponding parts of the germ which it fecundates. It is not *moulded* in different parts of the male, in his larynx, ears, &c. What idea could be formed of the mould of a larynx, of an ear, &c.? Here our philosopher forbears to draw immediate consequences, and gives warning that he does so. He refers to some of his first principles, and examines their results afresh. The fecundating liquor penetrates the germ, it modifies certain parts of it; it therefore acts on these parts, causes them to grow, and frequently to excess, consequently it nourishes them, incorporates itself with their substance, since growth is the natural and immediate effect of nutrition. Therefore it is not a mere *stimulus*, it is also an *alimentary liquor*. Divers facts lead to the same consequence. It is well known, that it is that which causes the comb of the cock, the stag’s horns, the beards, &c. to grow. Does not this nutritious quality likewise manifest itself by the failure of the voice, and the melancholy effects of consumption? All nutritious liquor should have a certain relation with the actual state of the parts to be nourished; if these parts are extremely delicate, this liquor must be very subtile and highly elaborated. If it produces great changes in them, we may from thence justly conclude, that it is endued with a singular activity; and as each part has its proper texture, which undoubtedly results from the nature of those elements and their combinations, so the nutritious liquor must contain molecules analogous to those elements; for nothing seems more disposed to favour the union of alimentary particles than their affinity. One drop of water unites with another; a drop of water and a drop of oil mutually repel each other. The fecundating liquor then is extremely subtile, compounded, and active. It is, in all likelihood, conveyed to the heart of the germ; since it augments its irritability, and consequently its impulsive force. It is probably then forced into the larynx, since it modifies all the parts of it. These parts, therefore, in their turn contain those determinations which render them modifiable. We do not know wherein those determinations consist; but we are very sensible that the fecundating liquor would in vain act on these parts, if they had no relation with the method of acting in this liquor. The particular qualities of animal

mal liquors seem to depend ultimately on the structure of the organs that filtre, prepare, and elaborate them. A liquor destined to nourish all these parts should probably comprise in it principles analogous to the elements of all the parts. It is not unlikely then, that the liquor of the afs contains in it something relative to his larynx, ears, &c. Therefore the organs which prepare this liquor are constructed in a certain relation to the different parts of the body. The amazing composition of these organs, and the no less astonishing composition of the microscopical anatomy, aided by injections, discovered in the analogous structure of the viscera, strengthen a conjecture that seems naturally to arise from an examination and comparison of facts. A well-known experiment reflects new light upon this, when attentively considered; it is that of grafting the cock's spur on his comb. This spur, after some time, becomes a real horn of several inches in length. This remarkable horn joints itself with the head, by parts of a refined structure, which, before the operation, did not appear to exist either in the head or spur. We must not, however, imagine that the simple operation of inserting the spur into the comb has created new organs. If the spur had been left in its natural place, it would always have remained a spur. Being ingrafted into the comb, it has received a somewhat different nourishment, which has caused it to grow to excess, and has modified certain parts more or less, either of the spur, the head, or both together. What then cannot nutrition effect?

“This is a slight sketch of the method I have pursued in my endeavours to solve the mystery of *generation*. If I have advanced some principles that carry a degree of probability with them, in order to explain the formations of the *mule*, these principles may tend to explain all resemblances of the same kinds. They will always rest on the importance of the *pre-existence of the germ* to fecundation, I admit then, that if the falsity of this observation should ever be demonstrated, the edifice I have attempted to erect on that basis would be as ruinous as those I have undertaken to destroy.”—*Bonnet Contemplation de la Nature, Preface.*

EDITOR.

C H A P. XVI.

The Conclusion.

THUS I have, as briefly as well I could (and much more briefly than the matters deserved) dispatched the decal of things I proposed in common to the sensitive creatures. And now let us pause a little and reflect. And upon the whole matter, what less can be concluded than that there is a Being infinitely wise, potent, and kind, who is able to contrive and make this glorious scene of things, which I have thus given only a glance of? For what less than infinite, could stock so vast a globe with such a noble set of animals? All so contrived, as to minister to one another's help some way or other, and most of them serviceable to man peculiarly, the top of this lower world, and who was made, as it were, on purpose to observe, and survey, and set forth the glory of the infinite *Creator*, manifested in his works! Who! what, but the great God could so admirably provide for the whole animal world every thing serviceable to it, or that can be wished for, either to conserve its species, or to minister to the being or well-being of individuals! Particularly, who could *feed* so spacious a world, who could please so large a number of palates, or suit so many palates to so great a variety of food, but the infinite Conservator of the world!

world! And who but the same great HE could provide such commodious *cloathing* for every animal; such proper *houses, nests, and habitations*; such suitable *armature and weapons*; such *subtilty, artifice, and sagacity*, as every creature is more or less armed and furnished with, to fence off the injuries of the weather, to rescue itself from dangers, to preserve itself from the annoyances of its enemies; and, in a word, to conserve itself, and its species! What but an infinite superintending power could so equally *balance* the several species of animals, and conserve the *numbers* of the individuals of every species so even, as not to over or under-people the terraqueous globe! Who, but the infinite wise LORD of the world, could allot every creature its most suitable *place* to live in, the most suitable element to *breathe, and move, and act* in. And who but HE could make so admirable a set of organs, as those of respiration are, both in land and water animals! Who could contrive so curious a set of limbs, joints, bones, muscles, and nerves, to give to every animal the most commodious motion to its state and occasions! And to name no more! What anatomist, mathematician, workman, yea angel, could contrive and make so curious, so commodious, and every way so exquisite a set of senses, as the *five senses* of animals are; whose organs are so dexterously contrived, so conveniently placed in the body, so neatly adjusted, so firmly guarded, and so completely suited to every occasion, that they plainly set forth the agency

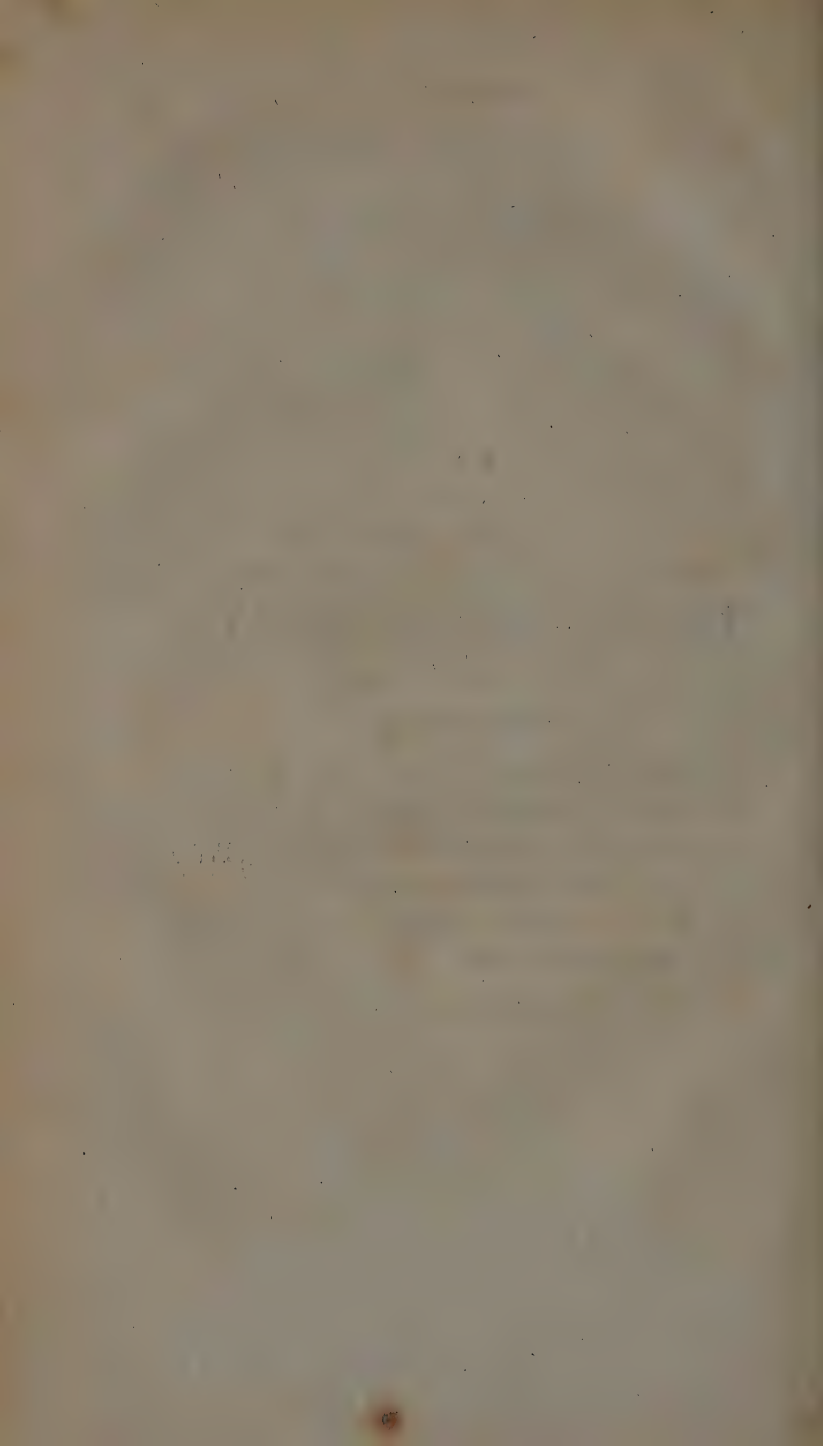
of the infinite Creator and Conservator of the world.

So that here, upon a transient view of the animal world in general only, we have such a throng of glories, such an enravishing scene of things as may excite us to admire, praise, and adore the infinitely wise, powerful, and kind CREATOR; to condemn all atheistical principles; and with holy *David*, *Psalms* xiv. 1. to conclude, that he is in good earnest a *fool*, that dares to say, *there is no GOD*, when we are every where surrounded with such manifest characters, and plain demonstrations of that infinite Being.

But in the next Book we shall still find greater tokens, if possible, when I come to take a view of animals in particular.

A
S U R V E Y
OF THE PARTICULAR
TRIBES OF ANIMALS.

In the foregoing Book, having taken a view of the things in common to Animals, my business in the next, will be to inspect the particular Tribes, in order to give further manifestations of the infinite Creator's wisdom, power, and goodness towards the animal world.



B O O K V.

A Survey of Man.

THE first *genus* of animals that I shall take notice of shall be MAN, who may justly claim the precedence in our discourse, inasmuch as GOD hath given him the superiority in the animal world; *Gen. i. 26. And God said, Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.*

And as to man, we have so excellent a piece of workmanship, such a microscopm, such an abridgment of the Creator's art in him, as is alone sufficient to demonstrate the Being and Attributes of GOD. Which will appear, by considering the *Soul* and the *Body* of man.

C H A P. I.

Of the Soul of Man.

MY survey of man, I shall begin with the Soul of man, by reason it is his most noble part (a) the copy of the divine image in us (b), in which we have enough to fill us with admiration of the munificence, power, and wisdom of the infinite

(a) *Jam verò animum ipsum, mentemque hominis, rationem, consilium, prudentiam, qui non divinâ curâ perfecta esse perspicit, is his ipsis rebus mihi videtur carere.*—"But as to the soul itself, the mind of man, the faculty of reason, understanding, prudence; he, methinks, who judges that they are not the result of Divine Prescience, is himself devoid of them."—*Cic. de Nat. Deor. l. 2. c. 59.*

(b) *Sensum à cœlesti demissum traximus arce,*

*Cujus egent prona, & terram spectantia : mundi,
Principio indulgit communis Conditor, illis
Tantum animas ; nobis animum quoque.*

"Reason, that best of gifts to man assign'd,
Pure emanation of the heavenly mind,
To brutes denied ; these have but life and sense,
But man the thinking soul." *JUVEN. Sat. xv. ver. 144.*

*Et cum non aliter possent mortalia fingi.
Adjunxit geminas, illæ cum corpore lapsæ
Intereunt : hac sola manet, bustoque superstes
Evolat.*

"Twofold the spirit or the soul of man ;
One to the body join'd its fate partakes
And sinks to dust ; the other soars aloft,
Superior to this earthly frame's decay."

*CLAUD. de 4 Consul. Hon.
Creator,*

Creator (*c*), when we contemplate the noble faculties of this our superior part, the vast reach and compass of its *understanding*, the prodigious quickness and piercingness of its *thought*, the admirable subtilty of its *invention*, the commanding power of its *wisdom*, the great depth of its *memory* (*d*), and in a word, its *divine nature and operations*.

But

(*c*) *Nam si quis nulli sectæ addictus, sed liberâ sententiâ rerum considerationem inierit, conspicatus in tantâ carniû ac succorum colluvie tantam mentem habitare; conspicatus item & cujusvis animalis constructionem (omnia enim declarant opificis sapientiam) mentis, quæ homini inest, excellentiam intelliget, tum opus de partium utilitate, quod prius exiguum esse sibi videbatur, perfectissimæ theologiæ verum principium constituet: quæ theologia multò est major atque præstantior totâ medicinâ.*—“For if any person, free from the dogmatism of opinions, shall with an unbiassed understanding, enter upon the consideration of Nature, and observe how this complicated mass of flesh and of juices is the residence of an intelligent mind, and shall compare the construction of the human body with that of other animals (for all are alike demonstrative of the skill of the Creator); he will thence more readily perceive the superior excellence of the human mind; and that admirable adaptation of the several parts of the body to their distinct uses, which at first might have been slightly regarded, will be found to constitute the true principle of the most perfect theology: a science of more importance and of superior excellence to the most complete system of medicine.”—*Galen. de Usu Part. l. 17. c. 1.*

(*d*) Among many examples that I could give of persons famous for memory, *Seneca's* account of himself may be one. *Hanc [memoriam] aliquando in me floruisse, ut non tantum ad usum sufficeret, sed in miraculum usque procederet, non nego. Nam & 2000 nominum recitata, quo ordine erant dicta, reddebam: & ab his*

But I shall not dwell on this, though the superior part of man, because it is the least known. Only there are two things I cannot easily pass by,

his qui ad audiendum præceptorem nostrum convenerunt, singulos versus à singulis datos, cum plures quàm 200 efficerentur, ab ultimo incipiens usque ad primum recitabam.—"I own that this faculty of memory was at one time so remarkable in me, that it was not only sufficient for every purpose of utility, but amounted even to a miracle. For I could repeat 2000 names in the very order in which they were told over; and of 200 different verses recited by those who attended the lectures of our master, I could repeat the whole in a reversed order proceeding backwards from the last to the first."—After which, mention is made of the great memory of *Latro Porcius*, (*charissimi mihi sodalis*,—"my most dear companion," *Seneca* calls him,) who retained in his memory all the declamations he had ever spoken, and never had his memory fail him, not so much as in one single word. Also, he takes notice of *Cyneas*, ambassador to the *Romans*, from king *Pyrrhus*, who in one day had so well learned the names of his spectators, that *postero die novus homo & senatum, & omnem urbanam circumfusam senatui plebem, nominibus suis persalutavit.*—"The next day this stranger was able to salute the whole senate, and all the surrounding populace by their names."—*Senec. Controvers. l. i. init.* Vide quoque *Plin. l. 7. c. 24.* where he also adds other examples, *viz. Cyrus rex omnibus in exercitu suo militibus nomina reddidit; L. Scipio populo Rom. Mithridates 22 gentium rex, totidem linguis jura dedit, pro concione singulas sine interprete affatus. Charmidas (seu potius Carneades)—quæ quis exegerat volumina in bibliothecis, legentis modo præsentavit.*—"King *Cyrus* knew the names of all the soldiers in his army. *L. Scipio* knew the whole Roman people. *Mithridates*, the sovereign of 22 different nations, gave laws to each, and harangued them all in their own tongues without an interpreter. *Charmidas* (or rather *Carneades*) would have repeated over any book that was required of him, in a library, as if he had been reading it."

because

because they manifest the especial concurrence and design of the infinitely wise Creator, as having a particular and necessary tendency to the management and good order of the world's affairs. The

First of which is the various *genii*, or *inclinations of men's minds* to this, and that, and the other businesses (*e*). We see how naturally men betake themselves to this and that employment: some delight most in learning and books, some in divinity, some in physic, anatomy, and botany, some in critical learning and philology, some in mathematics, some in metaphysics, and deep researches; and some have their delight chiefly in

(*e*) *Diversis etenim gaudet Natura ministris,
Ut fieri diversa queant ornantia terras.
Nec patitur cunctos ad eandem currere metam,
Sed varias jubet ire vias, variosque labores
Suscipere, ut vario cultu sit pulchrior orbis.*

“For Nature chooses various instruments
That various beauty may adorn her works;
Nor wills that all should run an even course,
But points to each a different path of life
And different toils; thus has the universe
Its endless infinitely changing grace.”

PALING. in *Scorp.*

Ὅτως, ὃ πάντεςσι θεὸς χάριεα δίδωσι

Ἀνδράσιν, &c. *Ita non omnibus hominibus sua dona dat Deus, neque bonam indolem, neque prudentiam, nec eloquentiam: alius namque vultum habet deformem; sed Deus formam eloquentiâ ornat, &c.* Homer. *Odyss.* 8. The like also in *Iliad.* 1. 3.

“With partial hand the Gods their gifts dispense,
Some greatly think, some speak with manly sense;
Here heaven an eloquence of form denies,
But wisdom the defect of form supplies.”

POPE'S *Odyss.*
mecha-

mechanics, architecture, war, navigation, commerce, agriculture; and some have their inclinations lie even to the servile offices of the world, and an hundred things besides.

Now all this is an admirably wise, as well as most necessary provision, for the easy and sure transacting the world's affairs; to answer every end and occasion of man, yea, to make man helpful to the poor helpless beasts, as far as his help is needful to them; and all, without any great trouble, fatigue, or great inconvenience to man; rather as a pleasure and diversion to him. For so far it is from being a toil, that the greatest labours (*f*), cares, yea, and dangers too, become pleasant to him who is pursuing his *genius*; and whose ardour of inclination eggs him forward, and buoys him up under all opposition, and carrieth

(*f*) Although Solomon declares, *Eccles. xii. 12. That much study is a weariness to the flesh*; yet we see with what pleasure and assiduity many apply themselves to it. Thus Cicero tells of Cato, whom he casually found in Lucullus's library, *M. Catonem vidi in bibliothecâ sedentem, multis circumfusum Stoicorum libris. Erat enim, ut scis, in eo inexhausta aviditas legendi, nec satiari poterat: quippe ne reprehensionem quidem vulgi inanem reformidans, in ipsâ curiâ solet legere sæpe, dum senatus cogeretur—ut heluo librorum—videbatur.*—"I have seen Marcus Cato sitting in his library with the books of the Stoic philosophers all scattered around him; for he had, as you know, an insatiable and inexhaustible thirst for study. He cared nothing for the idle reprehensions of the vulgar; but would occupy himself in reading even in the senate-house, while the senators were assembling, so that he seemed a perfect devourer of books."—*Cicero de Finib. l. 3. c. 2.*

him through every obstacle, to the end of his designs and desires.

II. The next is, the *inventive* power of the soul (g). Under which I might speak of many things; but I shall take notice only of two, because they manifest the particular concern and agency of the infinitely wise Creator. The

I. Is, that *man's invention* should reach to such a great variety of matters, that it should hit upon every thing that may be of any use, either to himself, or to human society, or that may any ways promote (what in him lies) the benefit of this lower part of the creation.

For the illustration of this, I might take a view of all the arts and sciences, the trades, yea the very tools they perform their labours and contrivances with, as numerous as their occasions and contrivances are various. Indeed, what is there that falleth under the reach of man's senses, that he doth not employ to some use and purpose for the world's good? The celestial bodies, the sun, the moon, with the other planets, and the fixed stars,

(g) *Mentem hominis, quamvis eam non videas, ut Deum non vides, tamen ut Deum agnoscis ex operibus ejus, sic ex memoriâ rerum, & inventione, & celeritate motûs, omnique pulchritudine virtutis vim divinam mentis agnoscito.*—"Thus, although you see not the mind of man any more than you see the Divinity, so in like manner as you acknowledge God from his works, you may perceive and recognize the divine nature of the mind, from the faculties of memory and of invention, from the quickness of its transitions, and from the moral beauty of the virtuous affections."—*Cicer. Tuscul. Quest. l. 1. c. 29.*

stars, he employs to the noble uses of astronomy, navigation, and geography. And, what a noble acumen, what a vast reach must the soul be endowed with, to invent those curious sciences of geometry and arithmetic, both specious and in numbers; and those nice and various instruments made use of by the geometrician, astronomer, geographer, and sailor? And lastly, what a wonderful sagacity is shewn in the science of optics, and particularly in the late invention of the telescope; wherewith new wonders are discovered among God's works in the heavens, as there are here on earth with the microscope and other glassies?

And as for this lower world, what material is there to be found; what kind of earth, or stone, or metal; what animal, tree, or plant, yea even the very shrubs of the field; in a word, what of all the excellent variety the Creator has furnished the world with, for all its uses and occasions, in all ages; what, I say, that man's contrivance doth not extend unto, and make some way or other advantageous to himself, and useful for building, cloathing, food, physick, or for tools or utensils, or for even only pleasure and diversion?

But now, considering the great power and extent of human invention,

2. There is another thing that doth farther demonstrate the superintendence of the great Creator and Conservator of the world; and that is, that things of great and absolutely necessary use have soon and easily occurred to the invention of man;

man; but things of little use, or very dangerous use, are rarely and slowly discovered, or still utterly undiscovered. We have as early as the *Mosaic* history, an account of the inventions of the more useful crafts and occupations: Thus *Gen. iii. 23. Adam was sent forth from the garden of Eden, by God himself, to till the ground.* And in the next chapter, his two sons *Cain* and *Abel*; the one was of the same occupation, a tiller of the ground; the other a keeper of sheep (*b*). And the posterity of these are in the latter end of *Gen. iv.* recorded, *Jabal, to have been the father of such as dwell in tents (i); i. e. he was the inventor of tents,* and pitching those moveable houses in the fields, for looking after, and depasturing their cattle in the deserts and uncultivated world. *Tubal-Cain was an instructor of every artificer in brass and iron (k),* or the first that found out the art of *melting and malleating (l) metals,* and making them useful for tools, and other necessary implements. And his sister *Naamah,* whose name is only mentioned, is by some thought to have been the inventor of *spinning and cloathing.* Yea, the very art of *music* is thus early ascribed to *Jubal (m);* so indulgent was the Creator to find a means to divert melancholy, to cheer the spirits, and to entertain

(*b*) *Gen. iv. 2.*

(*i*) *Vers. 20.*

(*k*) *Vers. 22.*

(*l*) Σφυροκόπος, the LXX call him, *i. e.* a worker with an hammer.

(*m*) *Vers. 21.*

ertain and please mankind. But for things of no use, or but little use, or of pernicious consequence; either they have been much later thought of, and with great difficulty and perhaps danger too brought to pass; or else they still are, and perhaps will always remain, exercises of the wit and invention of men.

Of this we might give divers instances: In mathematics, about squaring the circle (*n*); in mechanics,

(*n*) Although the *quadrature of the circle* hath in former ages exercised some of the greatest mathematical wits, yet nothing has been done in that way so considerable, as in and since the middle of the last century; when in the year 1657, those very ingenious and great men, Mr. *William Neile*, and my Lord *Brounker*, and Sir *Christopher Wren* afterwards, in the same year, geometrically demonstrated the equality of some curves to a strait line. Soon after which, others at home, and abroad, did the like in other curves. And not long afterwards, this was brought under an *analytical calculus*: The first specimen whereof that was ever published, Mr. *Mercator* gave in 1688, in a Demonstration of my Lord *Brounker's* Quadrature of the *Hyperbola*, by Dr. *Wallis's* reduction of a fraction, into an infinite series by division. But the penetrating genius of Sir *Isaac Newton* had discovered a way of attaining the quantity of all quadruple curves analytically, by his method of *fluxions*, some time before the year 1668, as I find very probable from an historical account, in a long letter of Mr. *Collins*, written in his own hand, and sent to *Richard Townley*, esq. of *Lancashire*, whose papers are in my hands. In that letter, Mr. *Collins* saith, that in September 1668, Mr. *Mercator* published his *Logarithmotechnia*, one of which he soon sent to Dr. *Barrow*, who thereupon sent him up some papers of Mr. *Newton's* [now Sir *Isaac*]; by which, and former communications made thereof by the author to the Doctor, it appears, that the said method was invented
some

chanics (*o*), about the art of flying; and in navigation, about finding the longitude. These things, although some of them in appearance innocent, yea perhaps very useful, yet remain for the most part secret; not because the discovery of most of them is more impossible or difficult than of many other things which have met with a discovery; nor is it for want of man's diligence therein, or his careful pursuit and enquiry after them (for perhaps, nothing already discovered hath been more eagerly sought after); but with much better reason (I am sure with greater humility and modesty) we may conclude it is, because the infinitely wise Creator and Ruler of the world hath been pleased to lock up these things from man's understanding and invention, for some reasons best known to himself, or because they might be of ill consequence and dangerous amongst men:

As
some years before by the said Mr. Newton, and generally applied. And then he goes on to give some account of the method; what it performs in the circle, &c.; what Mr. Gregory had done in that kind, *who intended to publish somewhat in Latin about it, but would not anticipate Mr. Newton, the first inventor thereof*; with much more of this nature. The design, I find, of that indefatigable promoter of mathematics, Mr. Collins, was to acquaint Mr. Townley, in his letter, with what had been done, and to get the assistance of that ingenious gentleman towards the completing a body of *Algebra*.

(*o*) I do not mention here the *perpetual motion* which hath exercised the mechanical wits for many ages; because it is a thing impossible, if not a contradiction: as the before-commended Dr. Clarke asserts in *Robaul. Phys.* p. 133.

As in all probability the art of flying would particularly be; an art which in some cases might be of good use, as to the geographer and philosopher; but in other respects might prove of dangerous and fatal consequence: As for instance, by putting it in man's power to discover the secrets of nations and families, more than is consistent with the peace of the world for man to know; by giving ill men greater opportunities to do mischief, which it would not lie in the power of others to prevent; and as one (*p*) observes, by making men less sociable: "For upon every true or false
 " ground of fear or discontent, and other occasions, he would have been fluttering away to
 " some other place; and mankind, instead of cohabiting in cities, would, like the eagle, have
 " built their nests upon rocks."

That this is the true reason of these matters, is manifest enough from holy scripture, and reason (*q*) also gives its suffrage thereto. The *scripture* expressly tells us, that *every good gift, and every perfect gift, is from above, and cometh down from the Father of Lights*, St. James, i. 17. Solomon, Prov. ii. 6. saith, *The Lord giveth wisdom; out of his mouth cometh knowledge and understanding*. And *Elibu* is very express, *Job*, xxxii. 8. *But there is*

(*p*) Grew's *Cosmol. Sacr.* l. 1. c. 5. sect. 25.

(*q*) *Nemo igitur vir magnus sine aliquo afflatu divino unquam fuit.*—"There never was any great man without a certain portion of divine inspiration."—*Cic. de Nat. Deor.* l. 2. c. 66.

is a spirit in man, and the inspiration of the Almighty giveth them understanding, Πνεῦν παντοκράτορος ἐστὶν ἡ διδάσκουσα, as the LXX render it, *the inspiratus, the afflatus of the Almighty, is their instructor, mistress, or teacher.* And in scripture, not only the more noble, superior acts of wisdom or science, but much inferior also, bear the name of wisdom, knowledge, and understanding, and are ascribed unto GOD. It is well known that *Solomon's* wisdom is wholly ascribed unto GOD; and the wisdom and understanding which GOD is said to have given him, 1 *Kings*, iv. 29. is particularly set forth in the following verses, by his great skill in moral and natural philosophy, in poetry, and probably in astronomy, geometry, and such other of the politer sciences, for which *Egypt* and the eastern nations were celebrated of old (r): *And Solomon's wisdom excelled the wisdom of all the children of the East country; and all the wisdom of Egypt. For he was wiser than all men, than Ethan, &c. And he spake 3000 proverbs: and his songs were 1005. And he spake of trees from the cedar to the hyssop of the wall (i. e. of all sorts of plants); also of beasts, fowl, creeping things, and fishes.* So likewise the wisdom of *Daniel*, and his

(r) *Ægypt*, and some of the eastern nations, are celebrated for their skill in polite literature, both in scripture and profane story: *Job* was of those parts; so were the Σοφοὶ and Μάγοι, the *Brachmans* and *Gymnosophists*. *Moses* and *Daniel* had their education in those parts: And *Pythagoras*, *Democritus*, and others, travelled into those parts for the sake of their learning.

three companions, is ascribed unto GOD, *Dan. i. 17.* *As for these four children, God gave them knowledge, and skill in all learning and wisdom; and Daniel had understanding in all visions and dreams.* And accordingly in the next chapter, *Daniel* acknowledgeth and praiseth God, *v. 20, 21.* *Daniel answered and said, Blessed be the name of God for ever and ever, for wisdom and might are his.—He giveth wisdom unto the wise, and knowledge to them that know understanding.* But not only skill in the superior arts and sciences, but even in the more inferior mechanic arts, is called by the same names, and ascribed unto GOD: Thus for the workmanship of the tabernacle, *Exod. xxxi. 2.* to *v. 6.* *See, I have called Bezaleel; and I have filled him with the spirit of God, in wisdom, and in understanding, and in all manner of workmanship: To devise cunning works, to work in gold, silver, and brass; and in cutting of stones to set them; and in carving of timber, to work in all manner of workmanship.* So the spinsters, weavers, and other crafts-people, are called wise-hearted, *Exod. xxxiv. 10. 25,* and other places. And in *Exod. xxxvi. 1,* &c. the LORD is said to have put this wisdom in them, and understanding to know how to work all these manner of works, for the service of the sanctuary. And lastly, to name no more instances, *Hiram*, the chief architect of *Solomon's* temple, is in *1 Kings, vii. 14.* and *2 Chron. ii. 14.* called a *cunning man, filled with wisdom and understanding, to work in gold, silver, brass, iron, stone, timber,*

purple, blue, fine linen, and crimson ; also to grave, and find out every device which should be put to him.

Thus doth the word of *God* ascribe the contrivances and crafts of men, to the agency or influence of the *Spirit of God* upon that of man. And there is the same reason for the variety of *genii* or *inclinations* of men also; which from the same scriptures may be concluded to be a designation and transaction of the same almighty Governor of the world's affairs. And who indeed but HE could make such a divine substance, endowed with those admirable faculties and powers as the rational soul hath; a being to bear the great Creator's vicegerency in this lower world, to employ the several creatures, to make use of the various materials, to manage the grand businesses, and to survey the glories of all the visible works of *God*; a creature, without which this lower world would have been a dull, uncouth, and desolate kind of globe? Who, I say, or what less than the *infinite GOD* could make such a rational creature, such a divine substance as the soul? For if we should allow the atheist any of his nonsensical schemes, the *Epicurean* his fortuitous concurrence of atoms, or the *Cartesian* (s) his created matter put in motion ;

(s) As we are not to *accuse* any *falsely*, so, far be it from me to detract from so great a man as *monieur Cartes* was; whose principles, although many have perverted to atheistical purposes, and whose notions have, some of them, but an ill aspect ;

tion; yet with what tolerable sense could he, in his way, produce such a divine, thinking, speaking, contriving substance as the soul is; endowed exactly with such faculties, power, and dispositions as the various necessities and occasions of the world require from such a creature? Why should not rather all the acts, the dispositions and contrivances of such a creature as man, if made in a mechanical way and not contrived by God, have been the same? Particularly, why should he not have hit upon all contrivances of equal use, early, as well as many ages since? Why not that man have effected it, as well as this, some thousands of years after? Why also should not all nations and all ages (*t*) improve in every thing, as well

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pect; yet I am unwilling to believe he was an atheist; since in his *Principia Philosophiæ*, and other of his works, he vindicates himself from this charge; and frequently shews, seemingly, a great respect for religion: besides, that many of his suspicious opinions are capable of a favourable interpretation, which will make them appear in a better form: Thus when he discardeth *Final Causes* from his philosophy, it is not a denial of them; but only excluding the consideration of them for the sake of free philosophising; it being the business of a divine rather than a philosopher, to treat of them.

(*t*) For ages of *learning* and *ignorance*, we may compare the present and some of the ages before the Reformation. The last century, and the few years of this, have had the happiness to be able to vie with any age for the number of learned men of all professions, and the improvement made in all arts and sciences: too many, and too well known to need a specification.

But for ignorance, we may take the ninth age, and so down to the Reformation; even as low as queen *Elizabeth*, although learning

as this or that age or nation (*u*) only? Why should the *Greeks*, the *Arabians*, the *Persians*, or the

learning began to flourish; yet we may guess how matters stood, even among the clergy, by her 53 *injunct.* No. 1559. *Such as are but mean readers, shall peruse over before, once or twice, the chapters and homilies, to the intent they may read to the better understanding of the people, the more encouragement of godliness.* Spar. Collect. p. 82. But this is nothing, in comparison to the ages before, when the monk said, *Græcum non est legi*—"It is Greek, and is not to be read;" or as *Espenceus* more elegantly hath it, *Græcè nōsse suspēdum, Hebraicè prope hæreticum*—"It is a suspicious thing to understand Greek, but to know Hebrew is almost a heresy." Which suspicion, (said the learned *Hakewill*,) *Rhemigius* surely was not guilty of in commenting upon *diffamatus*, 1 *Thef.* i. 8. who saith, that *St. Paul* somewhat improperly put that for *divulgatus*, not being aware that *St. Paul* wrote in *Greek*, and not in *Latin*. Nay, so great was their ignorance, not only of *Greek*, but of *Latin* too, that a priest baptized in *nomine Patria, & Filia, Spiritua Sancta*. Another suing his parishioners for not paving the church, proved it from *Jer.* xvii. 18. *Pavēant illi, non paveam ego*. Some divines in *Erasmus's* time undertook to prove heretics ought to be burnt, because the Apostle said, *hæreticum devota*. Two friars disputing about a plurality of worlds, one proved it from *annon decem sunt facti mundi?* The other replied, *Sed ubi sunt novem?* And notwithstanding their service was read in *Latin*, yet so little was that understood, that an old priest in *Hen.* VIII. read *Mumpsimus Domine*, for *Sumpsimus*: And being admonished of it, he said, he had done so for thirty years, and would not leave his old *Mumpsimus* for their new *Sumpsimus*. Vide *Hakew.* Apol. 1. 3. c. 7. sect. 2.

(*u*) There is (it seems) in wits and arts, as in all things beside, a kind of circular progress: They have their birth, their growth, their flourishing, their failing, their fading; and within a while after, their resurrection and reflowering again. The arts flourished for a long time among the *Persians*, the *Chaldeans*, the *Egyptians*.

the *Egyptians* of old, so far exceed those of the same nations now? Why the *Africans* and *Americans* so generally ignorant and barbarous, and the *Europeans*, for the most part, polite and cultivated, addicted to arts and learning? How could it come to pass, that the use of the magnet (*w*),
printing,

Egyptians.—But afterwards the Grecians got the start of them, and are now become as barbarous themselves as formerly they esteemed all besides themselves to be. About the birth of *Christ*, learning began to flourish in *Italy*, and spread all over *Christendom*; till the *Goths*, *Huns*, and *Vandals* ransacked the libraries, and defaced almost all the monuments of antiquity: so that the lamp of learning seemed to be put out for near the space of 1000 years, till the first *Manzor*, king of *Africa* and *Spain*, raised up, and spurred forward the *Arabian* wits, by great rewards and encouragements. Afterwards *Petrarch* opened such libraries as were undemolished. He was seconded by *Boccace*, and *John* of *Ravenna*, and soon after by *Aretine*, *Philadelphus*, *Valla*, &c. And those were followed by *Æneas Sylvius*, *Angelus Politianus*, *Hermolaus Barbarus*, *Marfilius Ficinus*, and *Job. Picus* of *Mirandula*. These were backed by *Rud. Agricola*, *Reuchlin*, *Melancthon*, *Joach. Camerarius*, *Wolphblazius*, *Beat. Rhenanus*, Germans: By *Erasmus* of *Rotterdam*: *Vives* a Spaniard: *Bembus*, *Sadoletus*, *Eugubinus*, Italians: *Turnebus*, *Muretus*, *Ramus*, *Pitheus*, *Budeus*, *Amiot*, *Scaliger*, Frenchmen: Sir *Tho. More* and *Linaker*, Englishmen. And about this time, even those northern nations yielded their great men: *Denmark* yielded *Olaus Magnus*, *Holfter*, *Tycho Brabe*, and *Hemingius*; and *Poland*, *Hosius*, *Frixius*, and *Crumerus*. But to name the worthies that followed these, down to the present time, would be endless, and next to impossible. See therefore *Hakevill's Apolog.* l. 3. c. 6. sect. 2.

(*w*) Dr. Gilbert, the most learned and accurate writer on the *Magnet*, shews, that its attractive virtue was known as early as *Plato* and *Aristotle*; but its direction was a discovery of later ages.

printing (x), clocks (y), telescopes (z), and an hundred things besides, should escape the discovery of
Archimedes,

ages. He saith, *Superiori ævo 300 aut 400 labentibus annis, motus magneticus in Boream & Austrum repertus, aut ab hominibus rursus recognitus fuit.*—"About 300 or 400 years ago, the motion of the magnetic needle, and its direction to the north and south, was either discovered, or the knowledge of the fact revived."—*De Mag.* l. i. c. i. But who the happy inventor of this lucky discovery was is not known. There is some, not inconsiderable, reason to think our famous countryman; *Rog. Bacon*, either discovered, or at least knew of it. But for its use in navigation, *Dr. Gilbert* saith, *In regno Neapolitano Melphitani omnium primi (uti ferunt) pyxidem instruebant nauticam: edocti à cive quodam Jol. Goia, A. D. 1300, ibid.*—"In the kingdom of Naples the people of Amalphi were the first who (as it is said) constructed the mariners compass: They were taught by one *Jol. Goia*."—If the reader hath a mind to see the arguments for the invention, being as old as *Solomon's* or *Plautus's* time, or of much younger date, he may consult *Hakewill*, ib. c. 10. sect. 4. or *Purchas Pilgr.* l. i. c. i. sect. 1:

As to the magnetic variation, *Dr. Gilbert* attributes the discovery of it to *Sebastian Cabott*. And the inclination of dipping of the needle, was the discovery of our ingenious *Rob. Norman*. And lastly, the variation of the variation was first found out by the ingenious *Mr. H. Gellibrand*, astr. prof. of *Gresham Col.* about 1634. *Vide Gellibr. Disc. Math. on the Variation of the Mag. Need. and its Variat. Anno 1635.*

But since that, the before-commended *Dr. Halley*, having formerly, in *Philos. Transf.* No. 148, and 195, given a probable hypothesis of the variation of the compass, did in the year 1700, undertake a long and hazardous voyage, as far as the ice near the south pole, in order to examine his said hypothesis, and to make a system of the magnetical variations: Which being soon after published, has been since abundantly confirmed

Archimedes, Anaximander, Anaximenes, Posidonius,
or other great virtuoso's of the early ages, whose
contri-

confirmed by the *French*, as may be seen in several of the late *Memoires de Physique & de Mathematique*, published by the French *Academie des Sciences*.

To these discoveries, I hope the reader will excuse me, if I add one of my own, which I deduced some years ago, from some magnetical experiments and observations I made; which discovery I also acquainted our Royal Society with some time since, *viz.* that as the common horizontal needle is continually varying up and down towards the E. and W., so is the dipping-needle varying up and down towards or fromwards the zenith, with its magnetic tendency, describing a circle round the pole of the world, as I conceive, or some other point. So that if we could procure a needle so nicely made, as to point exactly according to its magnetic direction, it would, in some certain number of years, describe a circle, of about 13 *gr.* radius round the magnetic poles northerly and southerly. This I have for several years suspected, and have had some reason for it too, which I mentioned three or four years ago at a meeting of our *Royal Society*; but I have not yet been so happy to procure a tolerable good dipping-needle, or other proper one to my mind, to bring the thing to sufficient test of experience, as in a short time I hope to do, having lately hit upon a contrivance that may do the thing.

(*) It is uncertain who was the inventor of the art of *printing*; every historian ascribing the honour thereof to his own city or country. Accordingly, some ascribe the invention of it to *John Guttenburg*, a knight of *Argentine*, about 1440, and say, that *Fausus* was only his assistant. *Bertius* ascribes it to *Laurence John*, of *Haerlem*, and saith, *Fust* or *Fauſt* stole from him both his art and tools. And to name no more, some attribute it to *John Fust* or *Fauſt*, and *Peter Schoeffer* (called by *Fust*, in some of his *imprimaturs*, *Pet. de Gernesheim puer meus*). But there is now to be seen at *Haerlem*, a book or two printed
by

contrivances of various engines, spheres, clepsydræ, and other curious instruments, are recorded?

by *Lau Koster*, before any of these, viz. in 1430 and in 1432. (See Mr. Ellis's *Letter to Dr. Tyson*, in *Phil. Transf.* No. 286.) But be the first inventor who he will, there is, however, great reason to believe the art received great improvements from *Fauſt*, and his son-in-law *Schoeffer*, the latter being the inventor of metalline types, which were cut in wood before, first in whole blocks, and afterwards in single types or letters. See my learned friend Mr. *Wanley's* Observations in *Philos. Transf.* Nos. 288 and 310.

(y) Concerning the antiquity and invention of *clocks* and *clock work*, I refer the reader to a little book, called *The Artificial Clockmaker*, chap. 6. where there is some account of the ancients inventions in clock-work, as *Archimedes's* Sphere, *Crescibius's* clock, &c.

(z) The invention of *telescopes*, *Hieron. Syrturus* gives this account of, *Prodiit anno 1609, seu genius, seu alter vir adhuc incognitus, Hollandi specie, qui Middleburgi in Zelandiâ convenit Joh. Lipperſein.—Fuſſit perſpicilla plura tam cava quam convexa confici. Condiçto die rediit, abſolutum opus cupiens, atque ut ſtatim habuit præ manibus, bina ſuſcipiens, cavum ſcil. & convexum, unum & alterum oculo admovebat, & ſenſim dimovebat ſive ut punctum concurſus, ſive ut artiſcis opus probaret, poſtea abiit. Artiſex, ingenii minimè expers, & novitatis curioſus cepit idem facere & imitari.—“ There appeared in the year 1609, a certain unknown ſtranger of the name of John Lipperſein, who came to Middleburg in Zealand, and ordered ſeveral glaſſes to be made, both convex and concave. He returned at the appointed time to receive them when finiſhed, and taking up two of them, viz. a concave and a convex, he held them up to his eye, gradually removing the one from the other, as if either to find the point of their concurrence, or to prove the work of the artiſer. Then he went away. The artiſt, who did not want genius, being ſtruck with the curioſity and novelty of the thing, began to make others and try the ſame experiments with them.”—*Vide M. ſ. Worm, l. 4. c. 7.**

ed (aa)? And why cannot the present or past age, so eminent for polite literature, for discoveries

(aa) Among the curious inventions of the ancients, *Archytas's* dove was much famed; of which *Aul. Gellius* gives this account: *Scriptserunt simulachrum columbæ è ligno ab Archytâ ratione quâdam disciplinâque mechanicâ factum, volâsse: ita erat scilicet libramentis suspensum, & aurâ spiritûs inclusâ utque occultâ concitum.*—"They write, that Archytas made the figure of a dove of wood, which, by some mechanical contrivance, could fly. It was dextrously poised and balanced, and was moved by the impulse of the air that was inclosed in it."—*Noÿ. Attic.* l. 10. c. 12. The same eminent *Pythagorean* philosopher (as *Favorinus* in *Gellius* calls him) is by *Horace* accounted a noble geometrician too,

Te maris & terræ, numeroque carentis arenæ

Mensorem; Archytâ—

"Thou, who couldst scan the earth and ocean's bound,

"And tell the countless sands that strew the shore,

"Archytas."

Among the rest of his inventions, *children's rattles* are ascribed to him. *Aristotle* calls them *Ἀρχύτης πλαταγή*; *Polit.* 8. i. e. *Archytas's rattle*. And *Diogenianus*, the Grammarian, gives the reason of his invention, *Ἀρχύτης πλαταγή ἐπὶ τῷ, &c.* That Archytas's rattle was to quiet children; for he having children, contrived the rattle, which he gave them to prevent their tumbling [*διασαλεύσῃσι*] other things about the house.

To these contrivances of *Archytas*, we may add *Regiomontanus's* wooden eagle, which flew forth of the city aloft in the air, met the emperor a good way off, coming towards it, and having saluted him returned again, waiting on him to the city gates. Also his iron-fly, which at a feast flew forth off his hands, and taking a round, returned thither again. Vide *Hakerwill*, ubi. *supr.* c. 10. *sect.* 1.

As to other inventions of the ancients, such as of letters, brick, and tiles, and building houses with the saw, rule, and plumber, the lath, auger, glue, &c. also the making brass, gold, and other metals; the use of shields, swords, bows, and arrows, boots, and other instruments of war; the pipe, harp, and other musical instruments, the building of ships and navigation,

coveries and improvements in all curious arts and businesses (perhaps beyond any known age of the world ; why cannot it, I say,) discover those hidden *quæsitæ*, which may probably be reserved for the discovery of future and less learned generations ?

Of these matters, no satisfactory account can be given by any mechanical hypothesis, or any other way, without taking in the superintendence of the great Creator and Ruler of the world ; who oftentimes doth manifest himself in some of the most considerable

tion, and many other things besides ; the inventors of these (as reported by ancient heathen authors) may be plentifully met with in *Plin. Nat. Hist.* l. 7. c. 56.

But in this account of *Pliny* we may observe whence the ancients (even the *Romans* themselves in some measure) had their accounts of these matters, *viz.* from the fabulous *Greeks*, who were fond of ascribing every thing to themselves. *The truth is* (saith the most learned bishop *Stillingfleet*) *there is nothing in the world useful or beneficial to mankind, but they have made a shift to find the author of it among themselves.* If we enquire after the original of agriculture, we are told of *Ceres* and *Triptolemus* ; if of pasturage, we are told of an *Arcadian Pan* ; if of wine, we presently hear of a *Liber Pater* ; if of iron instruments, then who but *Vulcan* ; if of music, none like to *Apollo*. If we press them then with the history of other nations, they are as well provided here ; if we enquire an account of *Europe*, *Asia*, or *Lybia* ; for the first, we are told a fine story of *Cædmus's sister* ; for the second, of *Prometheus's mother* of that name ; and for the third, of a daughter of *Epaphus*. And so the learned author goes on with other particular nations, which they boasted themselves to be the founders of. Only the grave *Athenians* thought scorn to have any father assigned them ; their only ambition was to be accounted *Aborigines* & *genuini terræ*. But the ignorance and vanity of the *Greek* history, that learned author hath sufficiently refuted. Vide *Stilling. Orig. Sacr. Part. 1. b. 1. c. 4.*

considerable of those works of men, by some remarkable transactions of his providence, or by some great revolution or other happening in the world thereupon. Of this I might instance in the invention of Printing (*bb*), succeeded first by a train of learned men, and the revival of learning, and soon after that by the Reformation, and the much greater improvements of learning at this day. But the most considerable instance I can give is, the progress of Christianity, by means of the civilised disposition, and large extent of the *Roman empire*. The latter of which, as it made way for human power; so the former made way for our most excellent religion into the minds of men. And so I hope, and earnestly pray, That the Omnipotent and all-wise Ruler of the world will transact the affairs of our most holy religion, ere it be long, in the heathen world; that the great improvements made in the last, and present age, in arts and sciences, in navigation and commerce, may be a means to transport our religion, as well as name, through all the nations of the earth. For we find that our culture of the more polite and curious sciences, and our great improvements in even the mechanic arts, have already made a way for us into some of the
largest

(*bb*) Whether *printing* was invented in 1440, as many imagine, or was sooner practised, in 1430, or 1432, as Mr. *Ellis's* account of the *Dutch* inscription in *Phil. Transf.* No. 286. doth import; it is however manifest, how great an influence (as it was natural) this invention had in the promoting of learning soon afterwards, mentioned before in *note* (*x*). After which followed the Reformation about the year 1517.

largest and farthest distant nations of the earth; particularly into the great empire of *China* (cc).

And now, before I quit this subject, I cannot but make one remark, by way of practical inference, from what has been last said; and that is, since it appears that the souls of men are ordered, disposed and actuated by God, even in secular, as well as spiritual Christian acts; a duty ariseth thence on every man, to pursue the ends, and answer all the designs of the Divine Providence, in bestowing his gifts and graces upon him. Men are ready to imagine their wit, learning, genius, riches, authority, and such like, to be works of nature, things of course, or owing to their own diligence, subtilty, or some secondary causes; that they are masters of them, and at liberty to use them as they please, to gratify

(cc) The *Chinese* being much addicted to judicial astrology, are great observers of the heavens, and the appearances in them. For which purpose they have an *observatory* at *Pekin*, and five mathematicians appointed to watch every night; four towards the four quarters of the world, and one towards the zenith, that nothing may escape their observation. Which observations are the next morning brought to an office to be registered. But notwithstanding this their diligence for many ages, and that the emperor hath kept in his service above 100 persons to regulate the kalendar, yet are they such mean astronomers, that they owe the regulation of their kalendar, the exactness in calculating eclipses, &c. to the *Europeans*; which renders the *European* mathematicians so acceptable to the emperor, that father *Verbieft*, and divers others, were not only made principals in the observatory, but put into places of great trust in the empire, and had the greatest honours paid them at their deaths. Vide *Le Comte Mem: of China*. Letter 2d, &c.

gratify their lust or humour, and satisfy their depraved appetites. But it is evident, That these things are the gifts of God, they are so many talents entrusted with us by the infinite Lord of the world, a stewardship, a trust reposed in us; for which we must give an account at the day when our Lord shall call; according to the parabolical representation of this matter by our blessed Saviour, *Matt. xxv. 14.*

Our duty then is not to abuse these gifts of God, *not to neglect the gift that is in us*, not to *hide our talent in the earth*; but as St. Paul exhorteth Timothy, *2 Tim. i. 6.* we must *stir up the gift of God which is in us*, and not let it lie idle, concealed or dead; but we must ἀναζωπυρεῖν τὸ χάρισμα, *blow it up, and enkindle it*, as the original imports; we must improve and employ our gift to the glory of the giver; or in that ministration, that use and service of the world, for which he gave it. Our stewardship, our craft, our calling, be it that of ambassadors of Heaven, committed to us, as it was to Timothy (*dd*), by the laying on of hands; or it be the more secular business of the gentleman, tradesman, mechanic, or only servant; nay, our good genius, our propensity to any good, as suppose to history, mathematics, botany, natural philosophy, mechanics, &c. I say, all these occupations, in which the providence of God hath engaged men, all the inclinations to which his spirit hath disposed them, ought to be discharged with that diligence, that care and fidelity, that

(*dd*) 1 Tim. iv. 14. 2 Tim. i. 6.

that our great Lord and Master may not say to us, as was said to the unfaithful steward, *Luke xvi. 2. Give an account of thy stewardship, for thou mayest be no longer steward*; but that he may say, as 'tis in the parable before cited, *Matth. xxv. 21. Well done thou good and faithful servant, thou hast been faithful over a few things, I will make thee ruler over many things, enter thou into the joy of thy Lord*. Since now the case is thus, let us be persuaded to follow Solomon's advice, *Ecclef. ix. 10. Whatsoever thy hand findeth to do, do it with thy might (ee)*: “ Lay hold
“ on every occasion that presents itself, and improve
“ it with the utmost diligence; because now is the
“ time of action, both in the employments of the
“ body, and of the mind; now is the season of
“ studying either arts and sciences, or wisdom and
“ virtue, for which thou wilt have no opportunities
“ in the place whither thou art going in the other
“ world. *For there is no work, nor device, nor
“ knowledge, nor wisdom in the grave whither thou
“ goest.*”

(ee) Bishop Patrick in loc.

CHAP. II.

Of Man's Body, particularly its Posture.

HAVING thus, as briefly as well I could, surveyed the *Soul*, let us next take a view of *man's Body*. Now here we have such a multiplicity of the most exquisite workmanship, and of the best contrivance, that if we should strictly survey the body from head to foot, and search only into the known parts (and many more lie undiscovered) we should find too large and tedious a task to be dispatched. I shall therefore have time only to take a transient and general kind of view of this admirable machine, and that somewhat briefly too, being prevented by others, particularly two excellent authors of our own (*a*), who have done it on the same account as myself. And the

I. Thing that presents itself to our view, is the *erect posture* (*b*) of man's body; which is far the most,

(*a*) *Mr. Ray, in his Wisdom of God manifested in the Works of Creation*, Part 2. And *Dr. Cockburn's Essays on Faith*, Part 1. Essay 5.

(*b*) *Ad hanc providentiam Naturæ tam diligentem* [of which he had been before speaking] *tamque solertem adjungi multa possunt, è quibus intelligatur, quantæ res hominibus à Deo, quamque eximie tributæ sunt: qui primùm eos humo excitatos, celsos & erectos constituit, ut Deorum cognitionem, cælum intuentes, capere possunt. Sunt enim è terrâ homines non ut incolæ, atque habitatores, sed quasi spectatores superarum rerum, atque cælestium, quarum spectaculum ad nullum aliud*

genus

most, if not the only commodious posture for a rational creature, for him that hath dominion over the other creatures, for one that can invent useful things, and practise curious arts. For without this erect posture, he could not have readily turned himself to every business, and on every occasion. His hand (c) particularly could not have been in so great a rea-

genus animantium pertinet.—"To these proofs of the singular care and providence of Nature, may be added many other facts equally demonstrative of the high and valuable attributes which God has assigned to the human race. For the Divinity has formed man thus raised from the earth, and erect in his stature, that the contemplation of the heavens might lead him to the intelligence of their almighty Author. For thus peculiarly distinguished is man from all other animals, that he seems less to be an inmate and inhabitant of this earth, than a contemplative spectator of that celestial world which is on high."—*Cic. de Nat. Deor.* l. 2. c. 56.

(c) *Ut autem sapientissimum animalium est homo, sic & manus sunt organa sapienti animali convenientia. Non enim quia manus habuit, propterea est sapientissimum, ut Anaxagoras dicebat; sed quia sapientissimum erat, propter hoc manus habuit, ut rectissime censuit Aristoteles. Non enim manus ipsæ hominem artes docuerunt, sed ratio. Manus autem ipsæ sunt artium organa, &c.*—"As man is the wisest of all animals, so the hands are the organs most suited to a being endowed with wisdom. For man is not wise because he has hands, as was the opinion of Anaxagoras, but Nature gave him hands because he was endowed with wisdom to make use of them, as Aristotle more rightly thought. It was not his hands that taught him the knowledge of the arts, but his reason; the hands are no more than the instruments of the arts."—*Galen de Us. Part.* l. 1. c. 3. After which, in the rest of this first book, and part of the second, he considers the particulars of the hand, in order to enquire, as he saith, *ch. 5. Num eam omnino constitutionem habeat [manus] quâ meliorem aliam habere non potuit.*—

a readiness to execute the commands of the will, and dictates of the soul. His eyes would have been the most

“Whether the hand had not that particular conformation because it could not have a better.”

Of this part, (and indeed of the other parts of human bodies) he gives so good an account, that I confess I could not but admire the skill of that ingenious and famed heathen. For an example, (because it is a little out of the way,) I shall pitch upon his account of the different length of the fingers. *Lib. 1. cap. 24.* The reason of this mechanism, he saith, is, That the tops of the fingers may come to an equality, *Cùm magnas aliquas moles in circuitu comprehendunt, & cùm in seipsis humidum vel parvum corpus continere conantur.*—*Apparent verò in unam circuli circumferentiam convenire digiti quinque in actionibus hujusmodi maximè quando exquisitè sphericum corpus comprehendunt.*—“When they lay hold of and grasp circularly any large body; and when they endeavour to contain in their cavity a liquid substance, or something of small bulk. But chiefly we may observe the five fingers meeting as it were in the circumference of a circle when they embrace a body of a spherical figure.”—And this evenness of the fingers ends, in grasping spherical, and other round bodies, he truly enough saith, makes the hold the firmer. And it seems a noble and pious design he had in so strictly surveying the parts of man's body, which take in his own translated words, *Cùm multa namque esset apud veteres, tam medicos, quam philosophos de utilitate particularum dissensio (quidam enim corpora nostra nullius gratiâ esse facta existimant, nullâque omnino arte; alii autem & aliqujus gratiâ, & artificiosè,—) primum quidem tantæ hujus dissensionis explicationem invenire studui; deinde verò & unam aliquam universalem methodum constituere, quâ singularum partium corporis, & eorum quæ illis accidunt utilitatem invenire possemus.*—“I was struck with those disputes among the antient physicians and philosophers about the utility of the parts; for some maintained that our bodies were not constructed with a view to any final cause, nor was there any artifice in their structure, while others contended that there was sufficient evidence of both. I therefore applied myself

most prone, and incommodiouſly ſituated of all animals; but by this ſituation, he can caſt his eyes upwards, downwards, and round about him; he hath a glorious hemisphere of the heavens (*d*), and an ample horizon on earth (*e*), to entertain his eye.

And

myself to find out, if poſſible, ſome criterion of the diſpute, and then endeavoured to eſtabliſh ſome general method for aſcertain- ing the utility of the ſeveral parts, and of the changes of which they are ſuſceptible."—*Ibid.* cap. 8.

(*d*) *Pronaque cum ſpectant animalia cætera terram,*

Os homini ſublime dedit, cælumque tueri

Juſſit, & erectos ad ſidera tollere vultus.

Ovid. *Metam.* l. i. car. 84.

Thus while the brute creation downward bend

Their ſight, and to their earthly mother tend,

Man looks aloft, and with erected eyes

Beholds his own hereditary ſkies. DRYDEN.

(*e*) If any ſhould be ſo curious, to deſire to know how far a man's proſpect reacheth, by means of the height of his eye, ſuppoſing the earth was an uninterrupted globe; the method is a common caſe of right-angled plain triangles, where two ſides, and an oppoſite angle are given: thus in plate M, *fig.* 5. *A H B* is the ſurface, or a great circle of the terraqueous globe; *C* the centre, *H C* its ſemi-diameter, *E* the height of the eye; and for- aſmuch as *H E* is a tangent, therefore the angle at *H* is a right angle: ſo that there are given *H C* 398,386 miles, or 21,034,781 *Engliſh* feet, (according to *book ii. chap. 2. note (a);*) *C E* the ſame length with the height of the eye, on the maſt of a ſhip, or at only a man's height, &c. added to it; and *E H C* the oppoſite right angle. By which three parts given, it is eaſy to find all the other parts of the triangle. And firſt, The angle at *C*, in order to find the ſide *H E*, the proportion is, as the ſide *C E*, to the angle at *H*; ſo the ſide *H C*, to the angle at *E*, which being ſubtracted out of 90 *gr.* the remainder is the angle at *C*. And then,

And as this erection of man's body is the most complete posture for him ; so if we survey the provision

then, as the angle at *E*, is to its opposite side *HC*, or else as the angle at *H* is to its opposite side *CE* ; so the angle at *C*, to its opposite side *EH*, the visible horizon. Or the labour may be shortened, by adding together the logarithm of the sum of the two given sides, and the logarithm of their difference ; the half of which two logarithms, is the logarithm of the side required, nearly. For an example, we will take the two sides in yards, by reason scarce any table of logarithms will serve us farther. The semi-diameter of the earth is 7,011,594 yards ; the height of the eye is two yards more, the sum of both sides, is 14,023,190.

Logar. of which sum is,	-	-	7,1468468
Logar. of two yards (the difference) is,			0,3010300
Sum of both logar.	-	-	<hr/> 7,4478768 <hr/>
The half sum,	-	-	<hr/> 3,7239384 <hr/>

is the logarithm of 5296 yards = three miles, which is the length of the line *EH*, or distance the eye can reach at six feet height.

This would be the distance, on a perfect globe, did the visual rays come to the eye in a strait line ; but by means of the rarefactions of the atmosphere, distant objects on the horizon appear higher than really they are, and may be seen at a greater distance, especially on the sea ; which is a matter of great use, especially to discover at sea the land, rocks, &c. and it is a great act of the Divine Providence, in the contrivance and convenience of the atmosphere, which by this means enlargeth the visible horizon, and is all one, as if the terraqueous globe was much larger than really it is. As to the height of the apparent above the true level ; or, how much distant objects are raised by the refractions, the ingenious and accurate gentlemen of the *French Academy Royal* have given us a table in their *Measure of the Earth*, Art. 12.

vifion made for it, we find all done with manifelt design, the utmoft art and fkill being employed therein. To pafs by the particular conformation of many of the parts, the ligaments and faftenings to anfwer this pofture; as the faftening, for inftance, of the *pericardium* to the *diaphragm*, (which is peculiar to man (*f*); I fay, paffing by a deal of this nature, manifelting this pofture to be an act of design,) let us ftop a little at the curious fabric of the bones, thofe pillars of the body. And how artificially do we find them made, how curioufly placed from the head to foot! The *vertebræ* of the neck and back-bone (*g*), made fhort and complanated, and firmly braced with mufcles and tendons, for eafy incurvations of the body; but withal for greater ftrength, to fupport the body's own weight, together with other additional weights it may have occafion to bear. The *thigh-bones* and legs long, and ftiong, and every way well fitted for the motion of the body. The *feet* accommodated with a great number of bones, curioufly and firmly tacked together, (to which muft be added the miniftry of the mufcles (*h*), to anfwer all the motions of the legs and

(*f*) See book vi. chap. 5. note (*g*).

(*g*) See book iv. chap. 8. note (*c*); and Plate A, fig. 2.

(*h*) The mechanifm of the foot would appear to be wonderful, if I fhould defcend to a defcription of all its parts; but that would be too long for thefe notes; therefore a brief account, (moft of which I owe to the before commended Mr. *Chefelden*,) may ferve for a fample: in the firft place, it is neceffary the foot fhould be concave, to enable us to ftand firm, and that the nerves

and thighs, and at the same time to keep the body upright, and prevent its falling, by readily assisting against every vacillation thereof, and with easy and ready touches keeping the *line of innexion* and *centre of gravity* in due place and posture (i).

And as the bones are admirably adapted to prop; so all parts of the body are as incomparably placed to poise it. Not one side too heavy for the other; but all in nice equipoise: The shoulders, arms, and side equilibrated on one part; on the other part the *viscera* of the belly counterpoised with the weight of the scapular part, and that useful cushion of flesh behind.

And lastly, To all this we may add the wonderful concurrence, and ministry, of the prodigious
number

and blood-vessels may be free from compression when we stand or walk. In order hereunto, the long *flexors* of the toes cross one another at the bottom of the foot, in the form of a St. *Andrew's* cross, to incline the lesser toes towards the great one, and the great one towards the lesser. The *short flexors* are chiefly concerned in drawing the toes towards the heel. The *transversalis pedis* draws the outsides of the foot towards each other; and by being inserted into one of the *sesamoid* bones of the great toe, diverts the power of the *abductor muscle*, falsely so called, and makes it become a *flexor*. And lastly, The *peroneus longus* runs round the outer ankle, and obliquely forwards crosses the bottom of the foot, and at once helps to extend the *tarsus*, to constrict the foot, and to direct the power of the other *extensors* towards the ball of the great toe: Hence the loss of the great toe is more than of all the other toes. See also Mr. *Cowper's Anat.* tab. 28. &c.

(i) It is very well worth while to compare here what *Borelli* saith, *de Motu Animal.* Par. 1. cap. 18. *De Statione Animal.* Prop. 132, &c. To which I refer the reader, it being too long to recite here.

number and variety of muscles, placed throughout the body for this service; that they should so readily answer to every posture; and comply with every motion thereof, without any previous thought or reflex act, so that (as the excellent *Borelli* (*k*) saith), “ It is worthy of admiration, that in so great
“ a variety of motions, as running, leaping, and
“ dancing, Nature’s laws of equilibration should
“ always be observed; and when neglected, or wil-
“ fully transgressed, that the body must necessarily
“ and immediately tumble down.”

(*k*) Borel. *ibid.* Prop. 142.

CHAP. III.

Of the Figure and Shape of Man's Body.

THE figure and shape of man's body is the most commodious that could possibly be invented for such an animal; the most agreeable to his motion, to his labours, and all his occasions. For had he been a rational reptile, he could not have moved from place to place fast enough for his business, nor indeed have done any almost. Had he been a rational quadruped, among other things, he had lost the benefit of his hands, those noble instruments of the most useful performances of the body. Had he been made a bird, besides many other great inconveniences, those before-mentioned of his flying would have been some. In a word, any other shape of body but that which the All-wise Creator hath given man, would have been as incommodious as any posture but that of erect; it would have rendered him more helpless, or have put it in his power to have been more pernicious, or deprived him of ten thousand benefits, or pleasures, or conveniences, which his present figure capacitates him for.

CHAP. IV.

Of the Stature and Size of Man's Body.

AS in the figure, so in the stature and size of man's body, we have another manifest indication of excellent design. Not too pigmean (*a*), nor too gigantic (*b*), either of which sizes would, in some particular or other, have been incommodious to himself, or to his business, or to the rest of his fellow creatures. Too pigmean would have rendered him too puny a lord of the creation; too impotent, and unfit to manage the inferior creatures; would have exposed him to the assaults of the weakest animals, to the ravening appetite of voracious birds, and have put him in the way, and endangered

(*a*) What is here urged about the size of man's body, may answer one of *Lucretius's* reasons, why *Nil ex nihilo gignitur*,—"Nothing is formed from nothing." His argument is, -

*Denique cur homines tantos natura parare
Non potuit, pedibus qui pontum per vada possent
Transire, & magnos manibus divellere montes?*

Why Nature, lavish of her gifts to man,
Denied him limbs to ford the sea, or arms,
Whose strength could tear the mountains from their base.

Lucret. l. 1. carm. 200.

(*b*) *Haud facile fit ut quisquam & ingentes corporis vires, & ingenium subtile habeat.*—"It seldom happens that the same person is endowed with great bodily strength, and with acuteness of genius."—*Diodor. Sic. l. 17.*

endangered his being trodden in the dirt by the larger animals. He would have been also too weak for his business, unable to carry burdens; and in a word, to transact the greater part of his labours and concerns.

And on the other hand, had man's body been made too monstrously strong, too enormously gigantic (c), it would have rendered him a dangerous tyrant

(c) Although we read of *giants* before *Noah's* flood, *Gen.* vi. 4. and more plainly afterwards in *Numb.* xiii. 33. yet there is great reason to think the size of man was always the same from the creation. For as to the *Nephilim*, or *giants*, in *Gen.* vi. the ancients vary about them; some taking them for great atheists, and monsters of impiety, rapine, tyranny, and all wickedness, as well as of monstrous stature, according as indeed the *Hebrew* signification allows.

And as for the *Nephilim*, in *Numb.* xiii. which were evidently men of a gigantic size, it must be considered, that it is very probable, the fears and discontentments of the spies might add somewhat thereunto.

But be the matter as it will, it is very manifest, that in both these places, *giants* are spoken of as rarities, and wonders of the age, not of the common stature. And such instances we have had in all ages; excepting some fabulous relations; such as I take to be that of *Theutobocchus*, who is said to have been dug up, anno 1613, and to have been higher than the trophies, and 26 feet long; and no better I suppose the giants to have been that *Ol. Magnus* gives an account of in his 5th book, such as *Harthen*, and *Starchater*, among the men; and among the women, *Reperta est* (saith he) *puella—in capite vulnerata, ac mortua, induta chlamyde purpureâ, longitudinis cubitorum 50, latitudinis inter humeros quatuor.*—"A young woman was found, dead of a wound in the head: she was clothed with a purple cloke, and measured in length 50 cubits, and four between the shoulders." —*Ol. Mag. Hist.* l. 5. c. 2.

But

tyrant in the world, too strong (*d*) in some respects, even for his own kind, as well as the other creatures.

But as for the more credible relations of *Goliath*, (*whose height was six cubits and a span*, 1 Sam. xvii. 4. which, according to the late curious and learned lord bishop of *Peterborough*, is somewhat above 11 feet *English*, *vid.* Bishop *Cumberland of Jewish weights and measures*) of *Maximinus* the emperor, who was nine feet high, and others in *Augustus*, and other reigns, of about the same height: to which we may add, the dimensions of a *skeleton*, dug up lately in the place of a *Roman* camp near *St. Alban's*, by an urn, inscribed, *Marcus Antoninus*; of which an account is given by Mr. *Chefelden*, who judgeth, by the dimensions of the bones, that the person was eight feet high. *Vide Philos. Trans.* No. 333. These antique examples and relations, I say, we can match, yea, out-do, with modern examples; of which we have divers in *J. Ludolph. Comment. in Hist. Æthiop.* l. 1. c. 2. sect. 22. *Magus, Conringius, Dr. Hakewill*, and others. Which latter relates from *Naunex*, of porters and archers belonging to the emperor of *China*, of 15 feet high; and others from *Purchas*, of 10 and 12 feet high, and more. See the learned author's *Apolog.* p. 208.

These indeed exceed what I have seen in *England*; but in 1684, I myself measured an *Irish* youth, said to be not 19 years old, who was seven feet near eight inches; and in 1697, a woman who was seven feet three inches in height.

But for the ordinary size of mankind, in all probability, it was always (as I said) the same, as may appear from the monuments, mummies, and other antient evidences to be seen at this day. The most antient monument at this day, I presume, is that of *Cheops*, in the first and fairest pyramid of *Egypt*; which was, no doubt, made of capacity every way sufficient to hold the body of so great a person as was intended to be laid up in it. But this we find, by the nice measures of our curious Mr. *Greaves*, hardly to exceed our common coffins. *The hollow part within* (saith he) *is in length only 6488 feet, and in breadth but 2218 feet: The depth 2860 feet. A narrow space, yet large enough*

tures. Locks and doors might perhaps have been made of sufficient strength to have barricaded our houses ;

enough to contain a most potent and dreadful monarch, being dead ; to whom living, all Egypt was too streight and narrow a circuit. By these dimensions, and by such other observations, as have been taken by me from several embalmed bodies in Egypt, we may conclude there is no decay in nature, (though the question is as old as Homer,) but that the men of this age are of the same stature they were near 3000 years ago. Vide Greaves of the Pyr, in 1638, in Ray's Collect. of Trav. tom. i, p. 118.

To this more antient, we may add others of a later date. Of which take these, among others, from the curious and learned *Hakewill*. The tombs at *Pisa*, that are some thousand years old, are not longer than ours ; so is *Athelstane's* in *Malmesbury* church ; so *Sehba's* in *St. Paul's*, of the year 693 ; so *Etheldred's*, &c. *Apol.* 216, &c,

The same evidence we have also from the armour, shields, vessels, and other utensils dug up at this day. The brass helmet dug up at *Metaurum*, which was not doubted to have been left there at the overthrow of *Asdrubal*, will fit one of our men at this day.

Nay, besides all this, probably we have some more certain evidence. *Augustus* was five feet nine inches high, which was the just measure of our famous queen *Elizabeth*, who exceeded his height two inches, if proper allowance be made for the difference between the *Roman* and our foot. *Vide Hakewill, ib.*

p. 215

(d) To the stature of men in the foregoing note, we may add some remarks about their unusual strength. That of *Sampson* (who is not said to have exceeded other men in stature, as he did in strength) is well known. So of old, *Hector*, *Diomedes*, *Hercules*, and *Ajax*, are famed ; and since them many others ; for which I shall seek no farther than the before-commended *Hakewill*, who, by his great and curious learning, hath often most of the examples that are to be met with on all his subjects he undertakes. Of the after-ages he names *C. Marius*, *Maxi-*
minus,

houfes; and walls, and ramparts might perhaps have been made ftrong enough to have fenced our cities.

minus, Aurelian, Scanderberge, Bacdefin, Tamerlane, Sifka, and Hunniades. Anno 1529, *Klunber*, provoft of the great church at *Mifnia*, carried a pipe of wine out of the cellar, and laid it in the cart. *Mayolus* faw one hold a marble pillar in his hand three feet long, and one foot diameter, which he toffed up in the air, and caught again, as if it were a ball. Another of *Mantua*, and à little man, named *Rodamas*, could break a cable, &c. *Ernando Burg* fetched up ftairs an afs laden with wood, and threw both into the fire. At *Constantinople*, anno 1582, one lifted a piece of wood, that 12 men could fcarce raife; then lying along, he bare a ftone that ten men could but juft roll to him. *G. of Fronsberge*, baron *Mindlebaim*, could raife a man off his feat, with only his middle finger; ftop an horfe in his full career; and shove a cannon out of its place. *Cardan* faw a man dance with two men in his arms, two on his foulders, and one on his neck. *Patacoua*, captain of the *Coffacks*, could tear an horfe-shoe (and if I miftake not, the fame is reported of the prefent king *Augustus* of *Poland*). A gigantic woman of the *Netherlands* could lift a barrel of *Hamburgh* beer. *Mr. Carew* had a tenant that could carry a butt's length, fix bufhels of wheaten meal (of 15 gallons meafure) with the lubber, the miller of 24 years of age, on the top of it. And *J. Roman* of the fame county, could carry the carcafe of an ox. *Vide Hakewill, ib. p. 238.*

Viros aliquot moderna memoria tam à mineralibus, quàm aliis Suethiæ & Gothiæ provinciis adducere congruit, tantâ fortitudine præditos, ut quisque eorum in humeros sublevatum equum, vel bovem maximum, imò vas ferri 600, 800, aut 1000 librarum (quale & aliquæ puellæ levare poffunt,) ad plura ftadia portaret.—"I could likewife repeat feveral instances from memory of men from the regions of the mines, as well as from the other provinces of Sweden and Gothland, who were endowed with fuch ftrength, that they could lift a horfe or an ox upon their foulders, or a vefſel

cities. But these things could not have been without a great and inconvenient expence of room, materials, and such necessaries, as such vast structures and uses would have occasioned; more perhaps than the world could have afforded to all ages and places. But let us take the descant of a good naturalist and physician on the case (*e*). “Had man been a dwarf
 “ (said he) he had scarce been a reasonable creature. For he must then have had a jolt head;
 “ so there would not have been body and blood
 “ enough to supply his brain with spirits; or he
 “ must have had a small head, answerable to his
 “ body, and so there would not have been brain
 “ enough for his business—Or had the species of
 “ mankind been gigantic, he could not have been
 “ so commodiously supplied with food. For there
 “ would not have been flesh enough of the best
 “ edible beasts to serve his turn. And if beasts
 “ had been made answerably bigger, there would
 “ not have been grass enough.” And so he goeth on. And a little after, “There would not have
 “ been the same use and discovery of his reason;
 “ in that he would have done many things by
 “ mere strength, for which he is now put to invent
 “ innumerable engines. Neither could he have
 “ used an horse, nor divers other creatures. But
 “ being

of 600, 800, or 1000 lbs. weight, and carry it (as indeed some young women could do) to the distance of several furlongs.” —
Ol. Mag. ubi supr.

(*e*) Grew's *Cosmol. Sacr.* b. 1. ch. 5. sect. 25.

“ being of a middle bulk, he is fitted to manage
“ and use them all. For (saith he) no other cause
“ can be assigned, why a man was not made five
“ or ten times bigger, but his relation to the
“ rest of the universe.” Thus far our curious
author.

CHAP. V.

Of the Structure of the Parts of Man's Body.

HAVING thus taken a view of the posture, shape, and size of man's body, let us in this chapter survey the structure of its parts. But here we have so large a prospect, that it would be endless to proceed upon particulars. It must suffice therefore to take notice, in general only, how artificially every part of our body is made. No botch, no blunder, no unnecessary *apparatus* (or in other words) no signs of chance (*a*); but every thing curious, orderly, and performed in the shortest and best method, and adapted to the most compendious use. What one part is there throughout the whole body, but what is composed of the fittest matter for that part; made of the most proper strength and texture;

(*a*) It is manifestly an argument of design, That in the bodies of different animals, there is an agreement of the parts, so far as the occasions and offices agree; but a difference of those, where there is a difference of these. In an human body are many parts agreeing with those of a dog for instance; but in his forehead, fingers, hand, instruments of speech, and many other parts, there are muscles, and other members which are not in a dog. And so contrariwise in a dog, which are not in a man. If the reader is minded to see what particular muscles are in a man, that are not in a dog; or in a dog, that are not in an human body, let him consult the curious and accurate anatomist, *Dr. Douglas's Myogr. Compar.*

ture; shaped in the completest form; and in a word, accoutred with every thing necessary for its motion, office, nourishment, guard, and what not! What so commodious a structure and texture could have been given to the bones, for instance, to make them firm and strong, and withal light, as that which every bone in the body hath? Who could have shaped them so nicely to every use, and adapted them to every part, made them of such just lengths, given them such due sizes and shapes, channelled, hollowed, headed, lubricated, and every other thing ministring, in the best and most compendious manner, to their several places and uses? What a glorious collection and combination have we also of the most exquisite workmanship and contrivance in the eye, in the ear, in the hand (*b*), in the foot (*c*),
in

(*b*) *Galen* having described the muscles, tendons, and other parts of the fingers, and their motions, cries out, *Considera igitur etiam hic mirabilem CREATORIS sapientiam!*—"Consider therefore in these the admirable wisdom of the CREATOR!"—*De Us. Part. l. i. c. 18.*

(*c*) And not only in the hand, but in his account of the foot (*l. 3.*) he frequently takes notice of what he calls *artem, providentiam & sapientiam Conditoris.*—"The skill, the providence, and the wisdom of the Creator." As *ch. 13.* *An igitur non æquum est hic quoque admirari providentiam Conditoris, qui ad utrumque usum, etsi certè contrarium, exactè convenientes & consentientes invicem fabricatus est totius membri [tibiæ] particulas?*—"Must we not therefore admire the providence of the Almighty Artificer, who has thus framed the parts of all our members, so wonderfully adapted to different and even contrary purposes?" And at the end of the chap. *Quòd si omnia quæ ipsarum sunt*
N 4 *partium.*

in the lungs, and other parts already mentioned? What an abridgment of art, what a variety of uses hath Nature laid upon that one member of the tongue, the grand instrument of taste, the faithful judge, the centinel, the watchman of all our nourishment, the artful modulator of our voice, the necessary servant of mastication, swallowing, sucking, and a great deal besides? But I must desist from proceeding upon particulars, finding I am fallen upon what I proposed to avoid.

And therefore for a close of this chapter, I shall only add part of a letter I received from the before-commended very curious and ingenious physician Dr. *Tancred Robinson*: *What (saith he) can possibly be better contrived for animal motion and life, than the quick circulation of the blood and fluids, which run out of sight in capillary vessels, and very minute ducts, without impediment, (except in some diseases,) being all directed to their peculiar glands and channels, for the different secretion, sensible and insensible;*

partium mente immutaverimus, neque invenerimus positionem aliam meliorem eâ quam nunc sortita sunt, neque figuram, neque magnitudinem, neque connexionem, neque (ut paucis omnia complectar) aliud quidquam eorum, quæ corporibus necessario insunt, perfectissimam pronuntiare oportet, & undique rectè constitutam præsentem ejus constructionem.—“ If we should set our minds to devise any alteration in the structure of those parts, we could find nothing more advantageous, either with respect to position, magnitude, or connection, but must rest satisfied, and pronounce that arrangement and construction, which they have at present, to be positively the best possible, and the most perfect.”—The like also concludes, ch. 15.

insensible; whereof the last is far the greatest in quantity and effects, as to health and sickness, acute distempers frequently arising from a diminution of transpiration, through the cutaneous chimneys, and some chronical ones from an augmentation: whereas, obstructions in the liver, pancreas, and other glands, may only cause a scirrhus, a jaundice, an ague, a dropsy, or other slow diseases. So an increase of that secretion may accompany the general colliquations, as in fluxes, hectic sweats and coughs, diabetes, and other consumptions. What a mighty contrivance is there to preserve these due secretions from the blood, (on which life so much depends,) by frequent attritions, and communications of the fluids in their passage through the heart, the lungs, and the whole system of the muscles? What meanders and contortions of vessels, in the organs of separation? And, what a concourse of elastic bodies from the air, to supply the springs, and continual motions of some parts, not only in sleep, and rest; but in long violent exercises of the muscles? Whose force drive the fluids round in a wonderful rapid circulation through the minutest tubes, assisted by the constant pabulum of the atmosphere, and their own elastic fibres, which impress that velocity on the fluids.

Now I have mentioned some uses of the air, in carrying on several functions in animal bodies; I may add the share it hath in all the digestions of the solid and fluid parts. For when this system of air comes, by Divine permittance, to be corrupted with poisonous, acrimonious steams, either from the earth, from mer-

5

chandise,

chandise, or infected bodies, what havoc is made in all the operations of living creatures? The parts gangrene, and mortify under carbuncles, and other tokens: indeed, the whole animal œconomy is ruined; of such importance is the air to all the parts of it. Thus my learned friend.

C H A P. VI.

Of the Placing the Parts of Man's Body.

IN this Chapter, I propose to consider the lodgement of the curious parts of man's body, which is no less admirable than the parts themselves, all set in the most convenient places of the body, to minister to their own several uses and purposes, and assist, and mutually to help one another. Where could those faithful watchmen the eye, the ear, the tongue be so commodiously placed, as in the upper part of the building? Where could we, throughout the body, find so proper a part to lodge four of the five senses, as in the head (*a*), near the
brain,

(*a*) *Sensus, interpretes ac nuntii rerum, in capite, tanquam in arce, mirifice ad usus necessarios & facti, & collocati sunt. Nam oculi tanquam speculatores, altissimum locum obtinent; ex quo plurima conspicientes, fungantur suo munere. Et aures cum sonum recipere debeant, qui naturâ in sublime fertur; rectè in illis corporum partibus collocatæ sunt.*—"The senses, which are as it were the interpreters and messengers of intelligence to the mind, are placed in the head, as in the citadel of the body, and are wonderfully adapted to their necessary purposes, both by their structure and position. For the eyes, as watchmen, are placed in the highest situation, that, by taking in a multiplicity of objects, they may thus more aptly discharge their duty. In like manner the ears are placed in an elevated situation, because it is the nature of sounds to ascend."—*Cicero de Nat. Deor.* l. 2. c. 55. *ubi plura de cæteris sensibus.*

brain(*b*), the common sensory, a place well guarded, and of little other use than to be a seat to those senses? And, how could we lodge the fifth sense, that of *touching*, otherwise(*c*), than to disperse it to all parts of the body? Where could we plant the hand(*d*), but just where it is, to be ready at every turn, on all occasions of help and defence, of motion, action, and every of its useful services? Where could we set the legs and feet but where they are, to bear up, and handsomely to carry about the body? Where could we lodge the heart, to labour about the whole mass of blood *, but in, or near the

(*b*) *Galen* well observes, that the nerves ministering to motion, are hard and firm, to be less subject to injury; but those ministering to sense, are soft and tender; and that for this reason it is, that four of the five senses are lodged so near the brain, *viz.* partly to partake of the brain's softness and tenderness, and partly for the sake of the strong guard of the skull. Vide *Gal. de Us. Part. l. 8. c. 5, 6.*

(*c*) See book iv. chap. 6. note (*c*).

(*d*) *Quàm verò aptas, quamque multarum artium ministras manus Natura homini dedit!*—"How admirably fitted by Nature are the hands for their offices; and to how many different arts do they minister!"—The particulars of which, enumerated by him, see in *Cic. ubi supra*, c. 60.

* The composition or structure of the blood itself is such as to render it capable of a free circulation, even in the most minute ramifications of the veins and arteries. Blood, when examined by the microscope, is found not to be a homogeneous fluid, but to consist of spherical particles of a red colour, floating in a transparent water or *serum*. I term them spherical particles, because,

according

the centre of the body (*e*)? Where could we find room for that noble engine to play freely in? Where could we so well guard it against external harms, as it is in that very place in which it is lodged and secured? Where could we more commodiously place,

(*e*) See book vi. chap. 5.

according to Mr. Hewson's very accurate observations, they are not globular, as was supposed by Mr. Lewenhoeck and Mr. Baker, but flat spheres. Each red particle is made up of six smaller; and Mr. Lewenhoeck has discovered that each of these again is composed of six particles, still more minute and colourless; so that every common red particle is compounded of at least 36 smaller ones, and perhaps the division may still go on much farther. Figure 1, Plate M, shews one of those large particles, wherein five of the smaller sort that compose it appear in contact, the sixth lying behind. Figure 2 shews how, by their mutual attraction to, or pressure against each other, they readily unite to form a perfectly circular body. It is highly probable that these six particles, and even the more minute ones, still whereof they are compounded, are occasionally separated, in order to pass through such extremely minute vessels, as without separation they cannot possibly enter, and are afterwards re-united when they meet again in the larger vessels. And we are certain that sometimes they cohere in greater numbers, and form larger masses, than are consistent with a free and healthy circulation. The structure or form of the blood vessels is most admirably fitted to prevent the blood from cohering in large masses, or coagulating. For in returning to the heart by the veins, as the smaller ramifications of these unite to form larger branches, at every such union of the smaller veins into a larger, there must be a collision of two currents rushing against each other with considerable force, by which collision unnatural cohesions are broken or prevented. Figure 3, representing the ramification of a vein, and the meeting of the currents at the point of junction of the different branches, will illustrate this observation.

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place, than in the thorax and belly, the useful *viscera* of those parts, so as not to swag, and jog, and over-set the body, and yet to minister so harmoniously, as they do, to all the several uses of concoction, sanguification, the separation of various ferments from the blood, for the great uses of Nature, and to make discharges of what is useless, or would be burdensome or pernicious to the body (*f*)? How could we plant the curious and great variety of bones, and of muscles, of all sorts and sizes, necessary, as I have said, to the support, and every motion of the body? Where could we lodge all the arteries and veins, to convey nourishment; and the nerves*, sensation throughout the body?

Where,

(*f*) *Ut in edificiis architecti avertunt ab oculis & naribus dominorum ea, quæ profluentia necessariò tetri essent aliquid habitura; sic Natura res similes (scil. excrementa) procul amandavit à sensibus.*—
 “As in the constructing of houses, a skilful architect removes from our sight and smell all nuisances or discharges which are offensive to either, so in the human body Nature has observed the same wise rule.”—*Cicer. de Nat. Deor.* l. 2. c. 56.

* The amazing extent of the ramification of the veins and nerves may be judged of from this circumstance, that neither the point of the smallest needle, nor the infinitely finer lance of a gnat, can pierce any part without drawing blood, and causing an uneasy sensation; consequently without wounding by so small a puncture, both a nerve and a vein. *Medical Extracts*, part 2. p. 18.

Dr. Johnstone's doctrine with respect to the use of the ganglions of the nerves is so ingenious in itself, and so consonant to the great scope of this work, that we cannot omit here shortly taking notice of it. It is the opinion of this learned writer, that

Fig. 1.



Fig. 2.

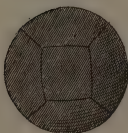


Fig. 3.



Fig. 6.

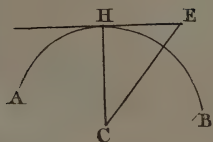


Fig. 4.

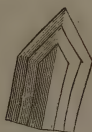


Fig. 5.

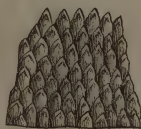


Fig. 1. A red particle of Blood, compounded of six smaller particles, each of which is made up of six still more minute. Fig. 2. A particle more compressed. Fig. 3. A ramification of a Vein, shewing the collision of the currents of blood at the junction of the branches. Fig. 4. One of the small scales which cover the cuticula or scarf skin. Fig. 5. Shews the manner in which these Scales are disposed on the surface of the skin.

Where, I say, could we lodge all these implements of the body, to perform their several offices? How could we secure and guard them so well, as in the very places, and in the self-same manner in which they are already placed in the body? And lastly, to name no more, what covering, what fence could we find out for the whole body, better than that of Nature's own providing, the skin (*g*)? How could we

(*g*) Compare here *Galen's Observations de Uf. Part. 1. 11. c. 15. Also l. 2. c. 6.* See also *Cowper Anat.* where in *Tab. 4.* are

that the ganglions are the immediate sources of all the involuntary motions; the instruments by which the motions of the heart and intestines are uniformly kept up. With respect to their structure, they may be considered as little brains or germs of the nerves detached from them, consisting of a mixture of cortical and nervous medullary substance, nourished by several small blood vessels, in which various nervous filaments are collected, so that a new nervous organization probably takes place in them. As to their uses, the ganglions appear to be the immediate origin of those nerves that are sent to organs moved involuntarily, and probably the check which hinders our volitions from extending to them. They are analogous to the brain in their office; subordinate springs and reservoirs of nervous power, and capable of dispensing it long after all communication with the brain is cut off. The vital organs derive their nervous power from them, and continue to move during sleep. Considered in this point of view, they have a very singular and useful office: they control the powers of the soul, and limit its authority in the animal machine. Hence we cannot, when under the unhappy influence of some moody or froward fit, arrest the motions of the heart by a mere volition; and thus, in one capricious moment, for ever lock up the springs of life.

—*Phil. Transf.* vol. liv. and lvii. EDITOR,

we shape it to, or brace it about every part better, either for convenience or ornament? What better

texture

are very elegant cuts of the skin in divers parts of the body, drawn from microscopical views; as also of the *papilla pyramides*, the *sudoriferous glands* and vessels, the hairs, &c.*

* The *cuticula* or scarf skin of the human body, is remarkable for its scales, and for its pores. Its scales are so minute as to be distinguishable only by the microscope. Mr. Baker computes that two hundred of them may be covered by a grain of sand. They are placed as on fishes; each scale being covered in part by two others, so that only a third part thereof is visible. The form of these scales is seen in Plate M at figure 4, and the manner in which they are disposed at figure 5. The perspirable matter issues between these scales which lie over the pores through which the watery and oily humours perspire. Every part of the human skin is full of excretory ducts or pores, whose purpose is to emit the superfluous humours continually from the mass of the circulating fluid. Mr. Lewenhoeck supposes there are 120 such pores in a line of one-tenth of an inch long, or moderately speaking at least 100. An inch in length will then contain 1000 in a row, and a foot 12,000. According to this computation, a foot square must have in it 144 millions; and supposing the superficies of a middle-sized man to be fourteen feet square, there will be in his skin 2016 millions of pores.

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Explanation of PLATE R.

This plate represents the heart *in situ*, all the large arteries and veins, and some of the muscles.

MUSCLES, &c.—SUPERIOR EXTREMITY. a Masseter; b Complexus; c Digastricus; d Os hyoides; e Thyroid gland; f Levator scapulæ; g Cucullaris; h h The clavicles cut; i The

texture could we give it, which, although less obdurate and firm than that of some other animals, yet

is

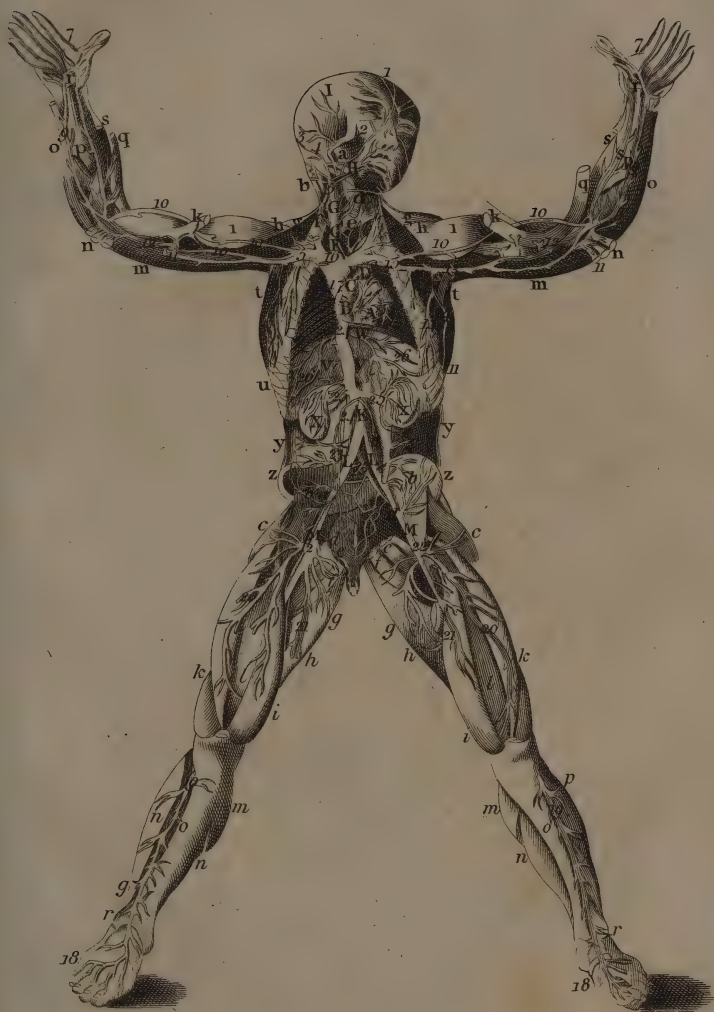
The deltoid muscle; k Biceps flexor cubiti cut; l Coracobrachialis; m Triceps extensor cubiti; n The heads of the pronator teres, flexor carpi radialis, and flexor digitorum sublimis cut; o The flexor carpi ulnaris, cut at its extremity; p Flexor digitorum profundus; q Supinator radii longus, cut at its extremity; r Ligamentum carpi transversale; s Extensores carpi radiales; t Latissimus dorsi; u Anterior edge of the serratus anticus major; v v The inferior part of the diaphragm; w w Its anterior edge cut; x x The kidneys; y Transversus abdominis; z Os ilium.

INFERIOR EXTREMITY. a Psoas magnus; b Iliacus internus; c The fleshy origin of the tensor vaginæ femoris; dd The ossa pubis cut from each other; e Musculus pectineus cut from its origin; f Short head of the triceps adductor femoris cut; g The great head of the triceps; h The long head cut; i Vastus internus; k Vastus externus; l Crureus; m Gemellus; n Soleus; o Tibia; p Peronæus longus; q Peronæus brevis; r Fibula.

HEART and BLOOD VESSELS. A The heart with the coronary arteries and veins; B The right auricle of the heart; C The aorta ascendens; D The left subclavian artery; E The left carotid artery; F The common trunk which sends off the right subclavian, and right carotid arteries; G The carotis externa; H Arteria facialis which sends off the coronary arteries of the lips; I Arteria temporalis profunda; K Aorta descendens; L L The iliac arteries which send off M M the femoral or crural arteries. N. B. The other arteries in this figure have the same distribution as the veins of the same name. 1, The frontal vein; 2, The facial vein; 3, Vena temporalis profunda; 4, Vena occipitalis; 5, Vena jugularis externa; 6, Vena jugularis interna, covering the arteria carotis communis; 7, The vascular arch on the palm of the hand, which is formed by 8, the radial artery and vein, and 9, the ulnar artery and vein; 10, 10, The cephalic vein; 11, Basilic vein, that on the right

is so much the more sensible of every touch, and more compliant with every motion? And being easily defensible by the power of man's reason and art, is therefore much the properest tegument for a reasonable creature.

side cut ; 12, Median vein ; 13, The humeral vein, which, with the median, covers the humeral artery ; 14, 14, The external thoracic or mammary arteries and veins ; 15, The axillary vein covering the artery ; 16, 16, The subclavian veins which, with (66) the jugulars, form 17, the vena cava superior ; 18, The cutaneous arch of veins on the fore-part of the foot ; 19, The vena tibialis antica, covering the artery ; 20, The vena profunda femoris, covering the artery ; 21, The upper part of the vena saphena major ; 22, The femoral vein ; 23, 23, The iliac veins ; 24, 24, Vena cava inferior ; 25, 25, The venal veins covering the arteries ; 26, 26, The diaphragmatic veins.



C H A P. VII.

Of the Provision in Man's Body against Evils.

HAVING taken a transient view of the structure, and lodgment of the parts of human bodies; let us next consider the admirable provision that is made throughout man's body, to stave off evils, and to discharge (*a*) them when befallen. For the prevention of evils, we may take the instances already given, of the situation of those faithful centinels, the eye, the ear, and tongue, in the superior part of the body, the better to descry dangers at a distance, and to call out presently for help. And how well situated is the hand to be a sure and ready guard to the body, as well as the faithful performer of most of its services? The brain, the nerves, the arteries, the heart (*b*), the lungs;

(*a*) One of Nature's most constant methods here, is by the *glands*, and the *secretions* made by them; the particulars of which being too long for these notes, I shall refer to the modern anatomists, who have written on these subjects; and indeed, who are the only men that have done it tolerably: particularly, our learned doctors *Cockburn*, *Keil*, *Morland*, and others at home and abroad: an abridgment of whose opinions and observations, for the reader's ease, may be met with in Dr. *Harris's Lex. Tech.* vol. ii. under the words *glands* and *animal secretion*.

(*b*) In man, and most other animals, the heart hath the guard of bones; but in the *lamprey*, which hath no bones, (no not so much as a backbone,) *the heart is very strangely secured, and lies*
immured,

lungs ; and in a word, all the principal parts, how well are they barricaded, either with strong bones, or deep lodgments in the flesh, or some such the wisest and fittest method, most agreeable to the office and action of the part? Besides which, for greater precaution, and a farther security, what an incomparable provision hath the infinite Contriver of man's body made for the loss of, or any defect in, some of the parts we can least spare, by doubling them? By giving us two eyes, two ears, two hands, two kidneys, two lobes of the lungs, pairs of the nerves, and many ramifications of the arteries and veins in the fleshy parts, that there may not be a defect of nourishment of the parts, in cases of amputation, or wounds, or ruptures of any of the vessels.

And as man's body is admirably contrived, and made to prevent evils ; so no less art and caution hath been used to get rid of them, when they do happen. When by any misfortune, wounds or hurts do befall ; or, when by our own wicked fooleries and vices, we pull down diseases and mischiefs upon ourselves, what emunctories (c), what admirable

immured, or capsulated in a cartilage, or grisly substance, which includes the heart, and its auricle, as the skull—doth the brain in other animals. Power's Microf. Obs. 22.

(c) *Here [from the pustules he observed in Monomotapa] were grounds to admire the contrivance of our blood, which on some occasions, so soon as any thing destructive to the constitution of it comes into it, immediately, by an intestine commotion, endeavoureth to thrust it forth, and is not only freed from the new guest, but sometimes what*
likewise

rable passages (*d*), are dispersed throughout the body; what incomparable methods doth Nature take (*e*); what vigorous efforts is she enabled to make,

likewise may have lain lurking therein—for a great while. And from hence it comes to pass, that most part of medicines, when duly administered, are not only sent out of the body themselves, but likewise great quantities of morbid matter: as in salivation, &c. Dr. Sloane's Voyage to Jamaica, p. 25.

(*d*) *Valsalva* discovered some passages into the region of the ear-drum, of mighty use, (among others,) to make discharges of bruises, imposthumes, or any purulent or morbid matter from the brain, and parts of the head. Of which he gives two examples: one, a person who, from a blow on his head, had dismal pains therein, grew speechless, and lay under an absolute suppression and decay of his strength; but found certain relief, whenever he had a flux of blood, or purulent matter out of his ear; which after his death, *Valsalva* discovered, was through those passages.

The other was an *apoplectical case*, wherein he found a large quantity of extravasated blood, making way from the ventricles of the brain, through those same passages. *Valsal. de Aure Hum. c. 2. sect. 14. and c. 5. sect. 8.*

(*e*) *Hippocrates, Lib. de Alimentis*, takes notice of the sagacity of Nature, in finding out methods and passages for the discharging things offensive to the body, of which the late learned and ingenious bishop of Clogher in Ireland (*Boyle*) gave this remarkable instance, to my very curious and ingenious neighbour and friend, *D'Acre Barret, Esq. viz.* That in the plague year, a gentleman at the university had a large plague sore gathered under his arm, which, when they expected it would have broken, discharged itself by a more than ordinary large and foetid stool; the sore having no other vent for it, and immediately becoming sound and well thereon.

Like to which, is the story of *Jos. Lazonius*, of a soldier of thirty-five years of age, who had a swelling in his right hip, ac-

make, to discharge the peccant humours, to correct the morbific matter; and in a word, to set all things right again? But here we had best take the advice of a learned physician in the case: “ The
 “ body (saith he) is so contrived, as to be well
 “ enough secured against the mutations in the
 “ air, and the lesser errors we daily run upon; did
 “ we not in the excesses of eating, drinking, think-
 “ ing,

complicated with great pain, &c. By the use of emollient medicines, having ripened the sore, the surgeon intended the next day to have opened it; but about midnight, the patient having great provocations to stool, disburdened himself three times; immediately upon which, both the tumour and pain ceased, and thereby disappointed the surgeon's intentions. *Ephem. Germ. anno 1690. Obs. 49.* More such instances we find of Mr. Tonges, in *Philosoph. Transf.* No. 323. But indeed there are so many examples of this nature in our *Philosoph. Transf.* in the *Ephem. German. Tho. Bartholine, Rhodius, Sennertus, Hildanus, &c.* that it would be endless to recount them. Some have swallowed knives, bodkins, needles and pins, bullets, pebbles, and twenty other such things as could not find a passage the ordinary way, but have met with an *exit* through the bladder, or some other way of Nature's own providing. But passing over many particulars, I shall only give one instance more, because it may be a good caution to some persons, that these papers may probably fall into the hands of; and that is, the danger of swallowing *plumb-stones, prune-stones, &c.* Sir Francis Butler's lady had many *prune-stones* that made way through an abscess near her navel. *Philosoph. Transf.* No. 265, where are other such like examples. More also may be found in No. 282, 304, &c. And at this day, a young man, living not far off me, laboureth under very troublesome and dangerous symptoms, from the stones of *stones* and *bullace*, which he swallowed eight or ten years ago.

“ ing, loving, hating, or some other folly, let in
 “ the enemy, or lay violent hands upon ourselves.
 “ Nor is the body fitted only to prevent ; but also
 “ to cure, or mitigate diseases, when by these fol-
 “ lies brought upon us. In most wounds, if kept
 “ clean, and from the air, the flesh will glue to-
 “ gether, with its own native balm. Broken bones
 “ are cemented with the *callus* which themselves
 “ help to make.” And so he goes on with ample
 instances in this matter, too many to be here speci-
 fied (*f*). Among which he instanceth in the di-
 stempers of our bodies, shewing, that even many of
 them are highly serviceable to the discharge of ma-
 lignant humours, and preventing greater evils.

And no less kind than admirable is this con-
 trivance of man’s body, that even its distempers
 should many times be its cure (*g*); that when the
 enemy

(*f*) Grew’s *Cosmol.* sect. 28, 29.

(*g*) *Nor are diseases themselves useles : for the blood in a fever, if well governed, like wine upon the fret, dischargeth itself of all heterogeneous mixtures ; and Nature, the disease, and remedies, clean all the rooms of the house ; whereby that which threatens death, tends, in conclusion, to the prolonging of life.* Grew, ubi supr. sect. 52.

And as diseases minister sometimes to health ; so to other good uses in the body, such as quickening the senses ; of which take these instances relating to the hearing and sight.

A very ingenuous physician falling into an odd kind of fever, had his sense of hearing thereby made so very nice and tender, that he very plainly heard soft whispers, that were made at a considerable distance off, and which were not in the least perceived by the bye-standers, nor would have been by him before his sickness.

A gentleman of eminent parts and note, during a distemper he had in his eyes, had his organs of sight brought to be so tender, that both

enemy lies lurking within to destroy us, there should be such a reluctance, and all Nature excited with its utmost vigour to expel him thence. To which purpose, even pain itself is of great and excellent use, not only in giving us notice of the presence of the enemy, but by exciting us to use our utmost diligence and skill to root out so troublesome and destructive a companion.

his friends and himself have assured me, that when he waked in the night, he could for a while plainly see and distinguish colours, as well as other objects discernible by the eye, as was more than once tried.
Boyl. Deter. Nat. of Effluv. ch. 4.

Daniel Frazer—continued deaf and dumb from his birth, till the 17th year of his age. After his recovery from a fever, he perceived a motion in his brain, which was very uneasy to him; and afterwards he began to hear, and in process of time, to understand speech, &c.
Vide Philos. Transf. No. 312.

C H A P. VIII.

Of the Consent between the Parts of Man's Body.

IT is an admirable provision the merciful Creator hath made for the good of man's body, by the consent and harmony between the parts thereof: Of which let us take St. Paul's description in 1 Cor. xii. 8. *But now hath God set the members, every one of them in the body, as it hath pleased him.* And ver. 21. *The eye cannot say unto the hand, I have no need of thee: nor again, the head to the feet, I no need of you.* But such is the consent of all the parts, or as the apostle wordeth it, *God hath so tempered the body together, that the members should have the same care one for another,* ver. 25. So that *whether one member suffer, all the members suffer with it; or one member be honoured, (or affected with any good,) all the members rejoice, [and sympathise] with it,* ver. 26.

This mutual accord, consent, and sympathy of the members, there is no reason to doubt (a), is made by the commerce of the nerves (b), and their
artificial

(a) See book iv. chap. 8.

(b) *Tria proposita ipsi Naturæ in nervorum distributione fuerunt.*

1. *Ut sensoriis instrumentis sensum impertiret.* 2. *Ut motoriis motum.*
3. *Ut omnibus aliis [partibus] daret ut quæ si dolorem adferrent, dignoscerent.* And afterwards, *Si quis in dissectionibus spectavit, considera-*

artificial positions, and curious ramifications throughout the whole body, which is admirable and incomparable, and might deserve a place in this survey, as greatly, and manifestly setting forth the wisdom and benignity of the great Creator; but that to give a description thereof from the origin of the nerves, in the *brain*, the *cerebellum*, and *spine*, and so through every part of the body, would be tedious, and intrench too much upon the anatomist's province: and therefore one instance shall suffice for a sample of the whole; and that shall be (what was promised before) (c) the great sympathy occasioned by the *fifth pair* of nerves; which I choose to instance in, rather than the *par vagum*, or any other of the nerves; because although we may have less variety of noble contrivance and art, than in that pair; yet we shall find enough for our purpose,

consideravitque justine, an secus Natura nervos non eadem mensurâ omnibus partibus distribuerit, sed aliis quidem liberalius, aliis verò parcius, eadem cum Hippocrate, vellet nollet, de Naturâ omnino pronuntiabit, quod ea scilicet sagax, justa, artificiosa, animaliumque provida est.—"Nature had chiefly three things in view in the distribution of the nerves. 1. To bestow an acute sensation in the instruments of sense. 2. To give the utmost facility of motion to the instruments of motion. And, 3. to confer in all the other parts a nice perception of whatever gives them pain. If any person shall attend to dissections, and consider attentively how Nature has not distributed the nerves in equal measure to all the different parts of the body, but to some more abundantly, and to others more sparingly, he will find himself compelled to acknowledge with Hippocrates, that Nature is eminently wise, just, skilful, and provident, in her arrangement of the animal economy."—*Galen. de Us. Part. 1. 5. c. 9.*

(c) *Book iv. chap. 5.*

Fig. 1.

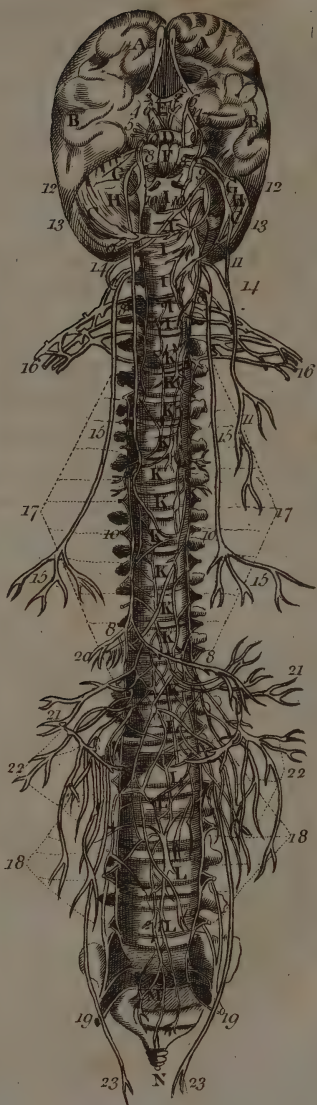


Fig. 2.

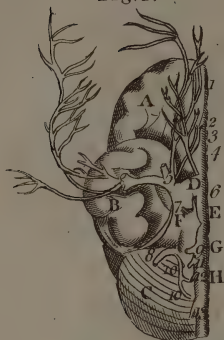


Fig. 3.



Fig. 4.

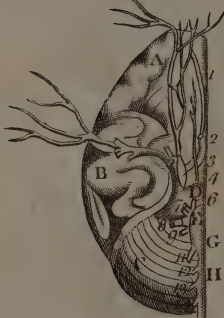
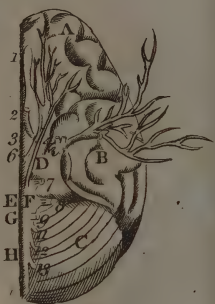


Fig. 5.



pose, and which may be dispatched in fewer words. Now this *fifth conjugation* of nerves, is branched to the ball, the muscles, and glands of the eye; to the ear; to the jaws, the gums, and teeth; to the muscles of the lips (*d*); to the tonsils, the palate, the tongue, and the parts of the mouth; to the *præcordia* also, in some measure, by inosculating with one of its nerves; and lastly, to the muscles of the face, particularly the cheeks, whose sanguiferous vessels it twists about *.

From

(*d*) Dr. Willis gives the reason, *cur mutua amasiorum oscula labiis impressa, tum præcordia, tum genitalia afficiendo, amorem ac libidinem tam facile irritant*, to be from the consent of those parts, by the branches of this fifth pair. *Nerv. Descr. c. 22.*

And Dr. Sachs judges it to be from the consent of the *labia oris cum labiis uteri*, that, in April 1669, a certain breeding lady, being affrighted with seeing one that had scabby lips, which they told her were occasioned by a pestilential fever, had such like pustules break out in the *labia uteri*. *Ephem. Germ. T. 1. Obs. 20.*

* *Explanation of PLATE C.*

Figure 1 represents the inferior part of the brain, the anterior part of the whole spine, including the medulla spinalis; with the origin and large portions of all the nerves; A A the anterior lobes of the cerebrum; B B its lateral lobes; C C the two lobes of the cerebellum; D tuber annulare; E the passage from the third ventricle to the infundibulum; F the medulla oblongata which sends off the medulla spinalis through the spine; K K the twelve dorsal vertebræ; L L the five lumbar vertebræ; M the os sacrum; N the os coccygis.—1, The first pair of nerves termed olfactory; 2, the second or optic; 3, the third motor oculi; 4, pair, pathetic which move the trochlear muscle of the eye; 5, the fifth pair, consisting of three branches, viz. ophthalmic, superior and inferior maxillary; 6, moving the abductor oculi; 7, auditory; 8, *par vagum*, spent on the tongue larynx, pharynx, lungs, and abdominal viscera; 9, spent on the tongue; 10, intercostal; 11, accessories; 12, cervical nerves; 13, second cervical; 14, third cervical; 15, the phrenic nerves; 16, brachial plexus; 17, twelve dorsal; 18, five lumbar;

From hence it comes to pass, that there is a great consent and sympathy(*e*) between these parts; so that a gustable thing seen or smelt, excites the appetite, and affects the glands and parts of the mouth; that a thing seen or heard, that is shameful, affects the cheeks with modest blushes; but on the contrary, if it pleases and tickles the fancy, that it affects the *præcordia*, and muscles of the mouth and face with laughter: but a thing causing sadness and melancholy, doth accordingly exert itself upon the *præcordia*, and demonstrate itself by causing the glands of the eyes to emit tears(*f*), and the muscles of the face to put on the sorrowful aspect of crying. Hence also that

(*e*) Consult *Willis, ubi supra*.

(*f*) Tears serve not only to moisten the eye, to clean and brighten the *cornea*, and to express our grief, but also to alleviate it, according to that of *Ulysses* to *Andromache*, in *Seneca's Troas*, ver. 762.

Tempus moramque dabimus, arbitrio tuo

Implere lacrymis: Fletus ærumnas levat.

“Thou shalt have ample time to vent thy tears;

For tears will ease thy sorrows.”

19, posterior crural; 20, the stomachic plexus formed by the eighth pair; 21, branches of the solar or cœliac plexus which supply the stomach, &c.; 22, branches of the mesenteric plexuses which supply the chylopoietic viscera with part of the organs of urine and generation; 23, nerves which accompany the spermatic chord; 24, the hypogastric plexus which supplies the organs of urine and generation within the pelvis.

Figures 2, 3, 4, and 5, shew different views of the inferior part of the brain cut perpendicularly through the middle, with the origin and large portions of all the parts which pass through the bones of the cranium, and the three first cervicals; A the anterior lobe; B the lateral lobe of the cerebrum; C one of the lobes of the cerebellum; D tuber annulare; E corpus pyramidale in the middle of the medulla oblongata; G the medulla oblongata; H the medulla spinalis; 1, 2, 3, 4, 5, 6, 7, 8, and 9, pairs of nerves; 10, 10, nervus accessorius which comes from 11, 12, and 13, the three first cervical nerves.

torvous four look produced by anger and hatred : and that gay and pleasing countenance accompanying love and hope. And, in short, it is by means of this communication of the nerves, that whatever affects the soul, is demonstrated (whether we will or no) by a consentaneous disposition of the *præcordia* within, and a suitable configuration of the muscles and parts of the face without. And an admirable contrivance of the great GOD of nature this is ; that as a face is given to man, and as *Pliny* saith (g), to man alone of all creatures ; so it should be (as he observes) *the index of sorrow and cheerfulness, of compassion and severity. In its ascending part is the brow, and therein a part of the mind too. Therewith we deny, therewith we consent. With this it is we shew our pride, which hath its source in another place ; but here its seat : in the heart it hath its birth ; but here it abides and dwells ; and that because it could find no other part throughout the body higher, or more craggy (h), where it might reside alone.*

Thus I have dispatched what I shall remark concerning the soul and body of man. There are divers other things, which well deserve a place in this survey ; and these that I have taken notice of, deserved to have been enlarged upon : but what hath been said, may suffice for a taste and sample of this admirable piece of God's handy-work ; at least serve as a supplement to what others have said before me. For which reason I have endeavoured to say as little wittingly as I could, of what they have taken notice of, except where the thread of my discourse laid a necessity upon me.

(g) *Plin. Nat. Hist. l. 11. c. 37.*

(h) *Nihil altius simul abruptiusque invenit.*—"It finds nothing higher or more abrupt."

CHAP. IX.

Of the Variety of Men's Faces, Voices, and Hand-writing.

HERE I would have put an end to my observations relating to man; but that there are three things so expressly declaring the Divine management and concurrence, that I shall just mention them, although taken notice of more amply by others; and that is, the great variety throughout the world of men's faces (*a*), voices (*b*), and hand-writing.

(*a*) If the reader hath a mind to see examples of men's likeness, he may consult *Valer. Maximus*, l. 9. c. 14. concerning the likeness of *Pompey* the Great, and *Vibius* and *Publicius Libertinus*; as also of *Pompey* the father, who got the name of *Cotquus*, he being like *Menogenes* the cook, with divers others.

(*b*) As the difference of tone makes a difference between every man's voice of the same country, yea, family, so a different dialect and pronunciation differs persons of divers countries; yea, persons of one and the same country speaking the same language. Thus in *Greece* there were the *Ionick*, *Dorick*, *Attick*, and *Æolick* dialects. So in *Great Britain*, besides the grand diversity of *English* and *Scotch*, the different counties vary very much in their pronunciation, accent, and tone, although all one and the same language. And the way of the *Gileadites* proving the *Ephraimites*, *Judg.* xii. 6. by the pronunciation of *Shibboleth*, with a *Schin*, or *Sibboleth* with a *Samech*, is well known. So à *Lapide* saith, the *Flemings* prove whether a man be a *Frenchman* or not, by bidding him pronounce *acht en tachtenticht*, which they pronounce *act en taclentic*, by reason they cannot pronounce the aspirate *h*.

writing. Had man's body been made according to any of the atheistical schemes, or any other method than that of the infinite Lord of the World, this wise variety would never have been; but men's faces would have been cast in the same, or not a very different mould; their organs of speech would have sounded the same, or not so great a variety of notes; and the same structure of muscles and nerves would have given the hand the same direction in writing. And in this case, what confusion, what disturbance, what mischiefs would the world eternally have lain under? No security could have been to our persons; no certainty, no enjoyment of our possessions (c); no justice between man and man; no distinction between good and bad, between friends and foes, between father and child, husband and wife, male or female; but all would have been turned topsy-turvy, by being exposed to

(c) *Regi Antiocho unus ex equalibus—nomine Artemon, perquam similis fuisse traditur. Quem Laodice, uxor Antiochi, interfecto viro, dissimulandi sceleris gratiâ, in lectulo perinde quasi ipsum regem ægrum collocavit. Admissumque universum populum, & sermone ejus & vultu consimili fefellit: credideruntque homines ab Antiocho moriente Laodicen & natos ejus sibi commendari.*—"A certain person named Artemon is said to have extremely resembled king Antiochus. Laodice, the wife of Antiochus, having put her husband to death, in the view of concealing her crime, put this man into a bed, as if he had been the sick king; and when the people were admitted to see him, he deceived them all by his speech and by his looks, so that they believed it was Antiochus himself who commended to their favour Laodice and her children."—*Valer. Max.* l. 9. c. 14.

to the malice of the envious and ill-natured, to the fraud and violence of knaves and robbers, to the forgeries of the crafty cheat, to the lusts of the effeminate and debauched, and what not. Our courts of justice (*d*), can abundantly testify the dire effects of mistaking men's faces, of counterfeiting their hands, and forging writings. But now, as the infinitely wise Creator and Ruler hath ordered the matter, every man's face can distinguish him in the light, and his voice in the dark; his hand-writing can speak for him though absent, and be his witness, and secure his contracts in future generations. A manifest, as well as admirable indication of the divine superintendence and management (*e*).

(*d*) *Quid Trebellius Calca! quàm asseveranter sese Clodium tulit! Et quidem dum de bonis ejus contendit, in centumvirale judicium adeò favorabilis descendit, ut vix justis Et æquis sententiis consternatio populi ullum relinqueret locum. In illâ tamen questione neque calumnia petitoris, neque violentiæ plebis judicantium religio cessit.*—"Why should I mention Trebellius Calca, or relate with what amazing confidence he maintained that he was Clodius; how the popular belief was so strong in his favour, that when he came to be heard before the centumviri, it almost overpowered the voice of equity and justice? But in that law-suit, the integrity and conscience of the judges withstood both the calumny of the claimant, and the violence of the people."—*Val. Max.* l. 9. c. 15.

(*e*) To the foregoing instances of divine management, with relation to the political state of man, I shall add another thing, that I confess hath always seemed to me somewhat odd, but very providential, and that is, the value that mankind, at least the civilized part of them, have in all ages put upon gems, and the purer finer metals, gold and silver, so as to think them
equivalent

equivalent unto and exchange them for things of the greatest use for food, cloathing, and all other necessities and conveniences of life. Whereas those things themselves are of very little, if any use in phyfic, food, building, or cloathing, otherwise than for ornament, or to minister to luxury ; as Suetonius tells us of *Nero*, who fished with a net gilt with gold, and shod his mules with silver ; but his wife *Poppæa* shod her horses with gold. *Vit. Ner.* c. 30. *Plin. N. H. L.* 33. c. 11. So the same Suetonius tells us, *Jul. Cæsar* lay in a bed of gold, and rode in a silver chariot. But *Heliogabalus* rode in one of gold, and had his close-stool pans of the same metal. And *Pliny* saith, *Vasa coquinaria ex argento Calvus orator fieri queritur.*—"Calvus the orator complains that even the utensils of the kitchen were made of silver." *Ibid.* Neither are those precious things of greater use to the making of vessels and utensils, (unless some little niceties and curiosities,) by means of their beauty, imperdibility, and ductility. Of which last, the great Mr. *Boyle* hath, among others, these two instances in his *Essay about the Subtily of Effluvioms*, ch. ii. *Silver, whose ductility and tractility are very much inferior to those of gold, was, by my procuring, drawn out to so slender a wire, that a single grain of it amounted to twenty-seven feet.* As to gold, he demonstrates it possible to extend an ounce thereof to reach to 777,600 feet, or 155 miles and a half, yea, to an incredibly greater length.

And as to gems, the very stories that are told of their prodigious virtues, are an argument that they have very little or none more than other hard stones. That a *diamond* should discover whether a woman be true or false to her husband's bed ; cause love between man and wife ; secure against witchcraft, plague, and poisons ; that the *ruby* should dispose to cheerfulness, cause pleasant dreams, change its colour against a misfortune befalling, &c. ; that the *sapphire* should grow foul and lose its beauty, when worn by one that is lecherous ; that the *emerald* should fly to pieces if it touch the skin of any unchaste person in the act of uncleanness ; that the *chrysolite* should lose its colour if poison be on the table, and recover it again when the poison is off ; and, to name no more, that the *turcoise* (and the same is said of a gold ring) should strike the hour when

hung over a drinking glass, and much more to the same purpose:—all these, and many other such fabulous stories, I say of gems, are no great arguments that their virtue is equivalent to their value. Of these, and other virtues, consult *Worm* in his *Museum*, l. 1. sect. 2. c. 17, &c.

But as to *gems* changing their colour, there may be somewhat of truth in that, particularly in the *turquoise* last mentioned. Mr. *Boyle* observed the spots in a *turquoise* to shift their place from one part to another by gentle degrees. So did the cloud in an *agate*-handle of a knife. A *diamond* he wore on his finger, he observed to be more illustrious at some times than others; which a curious lady told him she had also observed in hers. So likewise a rich *ruby* did the same. *Boyle of Absol. Rest in Bodies.*

CHAP. X.

The Conclusion of the Survey of Man.

AND now having taken a view of *man*, and finding every part of him, every thing relating to him contrived, and made in the very best manner; his body fitted up with the utmost foresight, art, and care; and this body (to the great honour, privilege, and benefit of man) possessed by a divine part, the *soul*, a substance made as it were on purpose to contemplate the works of God, and glorify the great Creator; and since this soul can discern, think, reason, and speak: what can we conclude upon the whole matter, but that we lie under all the obligations of duty and gratitude, to be thankful and obedient to, and to set forth the glories of our great Creator and noble Benefactor? And what ungrateful wretches are we, how much worse than the poor irrationals, if we do not employ the utmost power of our tongue, and all our members, and all the faculties of our souls in the praises of God! But above all, should we, who have the benefit of those glorious acts and contrivances of the Creator, be such wicked, such base, such worse than brutal fools, to deny the Creator (a) in some of his noblest works? Should

we

(a) It was a pious, as well as just conclusion, the ingenious *Laurence Bellini* makes of his *Opusculum de Motu Cordis*, in these

we so abuse our reason, yea, our very senses; should we be so befotted by the devil, and blinded by

words: *De Motu Cordis isthæc. Quæ equidem omnia, si à rudi intelligentiâ hominis tantum consilii, tantum ratiocinii, tantum peritiæ mille rerum, tantum scientiarum exigunt, ad hoc, ut inveniantur, seu ad hoc, ut percipiantur postquam facta sunt; illum, cujus operâ, fabricata sunt hæc singula, tam vani erimus atque inanes, ut existimemus esse consilii impotem, rationis expertem, imperitum, aut ignarum omnium rerum? Quantum ad me attinet, nolim esse rationis compos, si tantum insudandum mihi esset ad consequendam intelligentiam earum rerum, quas fabricaret nescio quæ vis, quæ nihil intelligeret eorum quæ fabricaret; mihi etenim viderer esse vile quiddam, atque ridiculum, qui vellem totam ætatem meam, sanitatem, & quicquid humanum est deterere, nihil curare quicquid est jucunditatum, quicquid lætitiarum, quicquid commodorum; non divitias, non dignitates; non pœnas etiam, & vitam ipsam, ut gloriari possem postremò invenisse unum, aut alterum, & fortasse me invenisse quidem ex iis innumeris, quæ produxisset, nescio quis ille, qui sine labore, sine curâ, nihil cogitans, nihil cognoscens, non unam aut alteram rem, neque dubiè, sed certò produxisset innumeras innumerabiles rerum in hoc tam immenso spatio corporum, ex quibus totus mundus compingitur, Ab, Deum immortalem! Video præsens numen tuum in hisce tam prodigiosis generationis initiis, & in altissimâ eorum contemplatione defixus, nescio quo æstro admirationis conciter, & quasi divine furens cõhiberi me mininè possum quin exclamem.*

Magnus Dominus! Magnus Fabricator hominum Deus! Magnus atque admirabilis! Conditor rerum Deus quàm magnus es!

—“ Now if all things which we have been considering require such an exertion of the limited understanding of man to find them out, and demand so much wisdom, knowledge, and scientific research to discover them after they are made, shall we be so utterly vain and foolish as to imagine that He, by whose power all these things were made, is himself devoid of wisdom, skill, and knowledge? For my part, I should see nothing desirable in possessing the faculty of reason, if I must bestow so much labour in attaining to the knowledge of

by our lusts, as to attribute one of the best contrived pieces of workmanship to blind chance, or unguided matter and motion, or any other such sottish, wretched, atheistical stuff, which we never saw nor ever heard made any one being (*b*) in any age

those things which are the operation of a blind and insensible agent ignorant of his own works. I should condemn myself as a being equally mean and ridiculous, for wasting my life and health, for setting at nought all considerations of pleasures, enjoyments, or conveniencies, and braving pain and death itself, for the vain boast of having discovered one or two of those innumerable works, which this unknown agent had produced without labour, skill, or consciousness: this being, who neither thinks nor understands, and yet, marvellous to tell, has produced every thing in this immeasurable space which we term the universe. O immortal God! I see, I acknowledge thy Divinity in these most wonderful rudiments of being; and penetrated with admiration, while I contemplate these stupendous instances of thy power and wisdom, my tongue cannot keep silence. Great is the Lord! Almighty Creator! Author of man, and Framers of the universe! how great and wonderful art Thou, O God omnipotent!"—*Bellin. de Mot. Cord. fin.*

(*b*) *Hoc [i. e. mundum effici ornatissimum, & pulcherrimum ex concursione fortuitâ] qui existimat fieri potuisse, non intelligo cur non idem putet, si innumerabiles unius, & viginti formæ literarum, vel aureæ, vel qualeslibet, aliquo conjiciantur, posse ex his in terram excussis annales Ennii ut deinceps legi possint, effici, &c.—Quod si mundum efficere potest concursus atomorum, cur porticum, cur templum, cur domum, cur urbem non potest? Quæ sunt minus operosa, & multò quidem faciliora.—*"He who imagines this universe, perfect and beautiful as it is, to be the work of chance, I see not why he may not likewise suppose, that if a vast number of alphabets, consisting of twenty-one letters, were thrown at random on the ground, they might produce the

age since the creation? No, No! but like wise and unprejudiced men, let us with *David* say, *Psalms* cxxxix. 14. (with which I conclude), *I will praise thee, for I am fearfully and wonderfully made, marvellous are thy works, and that my soul knoweth right well.*

Having thus made what (considering the copiousness and excellence of the subject) may be called a very brief survey of *man*, and seen such admirable marks of the divine design and art, let us next take a transient view of the other inferior creatures, and begin with quadrupeds.

works of *Ennius* as we now read them. But if the fortuitous concurrence of atoms could produce an universe, why might they not produce a portico, a temple, a house, or a city? for these surely require much less labour and skill."—*Cic. de Nat. Deor.* l. 2. c. 37.

B O O K VI.

A Survey of Quadrupeds.

C H A P I.

Of their prone Posture.

I N taking a view of this part of the animal world, so far as the structure of their bodies is conformable to that of man, I shall pass them by, and only take notice of some peculiarities in them, which are plain indications of design, and the Divine superintendence and management. And, 1. The most visible apparent variation is the *prone posture of their body*; concerning which I shall take notice only of two things, the parts ministering thereto, and the use and benefit thereof.

I. As for the parts, it is observable, that in all these creatures the *legs* are made exactly conformable to this posture, as those in man are to his erect posture. And what is farther observable also is, that the legs and feet are always admirably suited to the motion and exercises of each animal. In some they are made for strength only to sup-

port a vast unwieldy body (*a*); in others they are made for agility and swiftness (*b*); in some they are made for only walking and running; in others for that and swimming too (*c*); in others for walking

(*a*) The elephant being a creature of prodigious weight, the largest of all animals, *Pliny* saith, hath its legs accordingly made of an immense strength, like pillars rather than legs *.

(*b*) Deer, hares, and other creatures, remarkable for swiftness, have their legs accordingly slender, but withal strong, and every way adapted to their swiftness.

(*c*) Thus the feet of the *otter* are made, the toes being all conjoined with membranes, as the feet of geese and ducks are. And in swimming it is observable, that when the foot goes forward in the water the toes are close; but when backward they are spread out, whereby they more forcibly strike the water and drive themselves forward. The same may be observed also in ducks and geese, &c.

Of the *castor* or *beaver*, the *French* academists say, the structure of the feet was very extraordinary, and sufficiently demonstrated, that Nature hath designed this animal to live in the water, as well as upon land. For although it had four feet, like terrestrial animals, yet the hindmost seemed more proper to swim than walk with, the
five

* The legs of the elephant, the rhinoceros, and the sea-horse are made entirely for strength without any consideration of quickness of motion, for these animals have no need of swiftness of foot; they do not pursue other animals for food; and, conscious of their own strength, there are none that they deign to avoid. Deer, hares, and other creatures that are to find safety only in flight, have their legs made entirely for speed. Were it not for this advantage, they would be the prey of every carnivorous animal, and their race would soon be extinguished.

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ing and digging (*d*); and in others for walking and flying (*e*): in some they are made more lax and

five toes of which they were composed being joined together like those of a goose by a membrane, which serves this animal to swim with. But the fore ones were made otherwise, for there was no membrane which held those toes joined together; and this was requisite for the conveniency of this animal, which useth them as hands like a squirrel, when he eats. Memoirs for a Natural History of Animals, p. 84.

(*d*) The *mole's* feet are a remarkable instance.

(*e*) The wings of the *bat* are a prodigious deviation from Nature's ordinary way. So it is in the *Virginian squirrel*, whose skin is extended between the fore-legs and its body*.

* This animal is termed the *flying squirrel*. When it extends its legs the skin becomes distended like a sail, and by means of the buoyancy, which it thence acquires in the air, the animal is enabled to dart at one bound above 100 yards. Of the common squirrel Goldsmith relates, upon the authority of Klein and Linnæus, a most extraordinary fact: in Lapland, and the extensive forests of the north, the squirrels are observed to change their habitation, and to remove in vast numbers from one country to another. In these emigrations they are generally seen by thousands travelling directly forward, while neither rocks, forests, nor even the broadest waters can stop their progress. When they meet with a broad river or lake, on approaching its banks, and perceiving the breadth of the water, they return, as if by common consent, into the neighbouring forest, each in quest of a piece of bark to serve as a boat for wafting them over. When the whole company are fitted in this manner, they boldly commit their little fleet to the waves, each squirrel sitting on its own piece of bark, and fanning the air with its tail to drive the vessel to its desired port. In this orderly manner they set forward, and often cross
lakes

and weak for the plainer lands; in others rigid, stiff, and less flexible (*f*) for traversing the ice and dangerous precipices of the high mountains (*g*): in some they are shod with tough and hard hoofs, some whole, some cleft; in others with only a callos skin. In which latter it is observable, that the feet are composed of toes, some short for bare-going,

(*f*) Of the legs of the *elk*, the French academists say, although some authors report that there are elks in Muscovia, whose legs are jointless, there is great probability, that this opinion is founded on what is reported of those elks of Muscovia, as well as of Cæsar's Alce, and Pliny's Machlis, that they have legs so stiff and inflexible that they do run on ice without slipping, which is a way that is reported that they have to save themselves from the wolves, &c. Ibid. p. 108.

(*g*) The common tame goat, (whose habitation is generally on mountains and rocks, and who delighteth to walk on the tops of pales, houses, &c. and to take great and seemingly dangerous leaps,) I have observed, hath the joints of the legs very stiff and strong, the hoof hollow underneath, and its edges sharp. The like, I doubt not, is to be found in the wild goat, considering what Dr. Scheuchzer hath said of its climbing the most dangerous craggs of the *Alps*, and the manner of their hunting it. Vide *Iter. Alpin.* iii. p. 9.

lakes several miles in breadth. But it too often happens, that the poor mariners are not aware of the dangers of their navigation; for although at the edge of the water it is generally calm, they are frequently overtaken by a gust of wind in the middle of their passage, which discomfits and shipwrecks the whole navy. The Laplanders frequently find the shore spread with their dead bodies, and make a gainful prize of their skins.

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going, some long to supply the place of a hand (*b*), some armed with long and strong talons to catch, hold, and tear the prey; some fenced only with short nails to confirm the steps in running and walking.

II. As the posture of man's body is the fittest for a rational animal, so is the prone posture of *quadrupeds* the most useful and beneficial to themselves, as also most serviceable to man. For they are hereby better made for their gathering their food, to pursue their prey, to leap, to climb, to swim, to guard themselves against their enemies; and, in a word, to do whatever may be of principal use to themselves; as also they are hereby rendered more useful and serviceable to man, for carrying his burdens, for tilling his ground, yea, even for his sports and diversions.

And now I might here add a survey of the excellent contrivances of the parts ministering to this posture of the four-footed animals, the admirable structure of the bones (*i*), the joints and muscles, their various sizes and strength, their commodious
lodgment

(*b*) Thus in *apes* and *monkies*, in the *beaver* before, and divers others.

(*i*) It is a singular provision Nature hath made for the strength of the *lion*, if that be true, which *Galen* saith is reported of its bones being not hollow (as in other animals) but solid. Which report he thus far confirms, that most of the bones are so, and that those in the legs, and some other parts, have only a small and obscure cavity in them. Vide *Galen de Us. Part.* l. II. c. 18.

lodgment and situation, the nice equipoise of the body, with a great deal more to the same purpose. But I should be tedious to insist minutely upon such particulars ; and besides, I have given a touch upon these kinds of things when I spake of man.

Passing by, therefore, many things of this kind that might deserve remark, I shall only consider some of the parts of the *quadrupeds*, differing from what is found in man (*k*), and which are manifest works of design.

(*k*) *These sorts of differences in the mechanism of animals, upon the score of the position of their bodies, occur so often, that it would be no mean service to anatomy if any one would give us a history of those variations of the parts of animals which spring from the different postures of their bodies. Drake Anat. v. i. b. i. c. 17.*

C H A P. II.

Of the Heads of Quadrupeds.

IT is remarkable, that in man, the head is of one singular form; in the four-footed race, as various as their species. In some, square and large, suitable to their slow motion, food, and abode; in others, less, slender, and sharp, agreeable to their swifter motion, or to make their way to their food (*a*), or habitation under ground (*b*). But
passing

(*a*) Thus *swine*, for instance, who dig in the earth for roots and other food, have their neck, and all parts of their head very well adapted to that service. Their neck short, brawny, and strong; their eyes set pretty high out of the way; their snout long; their nose callous and strong; and their sense of smelling very accurate, to hunt out and distinguish their food in mud, under ground, and other the like places where it lies concealed.

(*b*) What hath been said of *swine* is no less, rather more, remarkable in the *mole*, whose neck, nose, eyes, and ears, are all fitted in the nicest manner to its subterraneous way of life*.

* In some animals the head is long, in order to give greater room for the olfactory nerves; as in dogs, who are to hunt and find out their prey by the scent. In others it is short and thick, as in the lion, to increase the strength of the jaw, and to fit it the better for combat. Quadrupeds that feed upon grass, are enabled to hold down their heads to the ground by a strong tendinous ligament, that runs from the head to the middle of the back. This serves to raise the head, although it has been held to the ground for a long space of time, without any labour to the animal, and without much stress to the muscles of the neck.

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passing by a great many observations that might be made of this kind, I shall stop a little at the brain, as the most considerable part of this part of the body, being the great instrument of life and motion in *quadrupeds*, as it is in man of that, as also in all probability the chief seat of his immortal soul. And accordingly it is a remarkable difference, that in man the brain is large, affording substance and room for so noble a guest; whereas in *quadrupeds*, it is but small. And another thing, no less remarkable, is the situation of the *cerebrum* and *cerebellum*, or the greater or lesser brain, which I shall give in the words of one of the most exact anatomists we have of that part (c): “ Since,” saith he “ God
 “ hath given to man a lofty countenance, to be-
 “ hold the heavens, and hath also seated an im-
 “ mortal soul in the brain, capable of the contem-
 “ plation of heavenly things; therefore, as his face
 “ is erect, so the brain is set in an higher place,
 “ namely, above the *cerebellum*, and all the sen-
 “ sories. But in brutes, whose face is prone to-
 “ wards the earth, and whose brain is incapable of
 “ speculation, the *cerebellum* (whose business it
 “ is to minister to the actions and functions of the
 “ *præcordia*, the principal office in those creatures)
 “ in them is situated in the higher place, and the
 “ *cerebrum* lower. Also some of the organs of
 “ sense,

(c) *Willis Cereb. Anat. cap. 6. Cumque huic Deus os sublime dederit, &c.*—“ As God has given him a lofty countenance,” &c.

“ sense, as the ears and eyes, are placed, if not
 “ above the *cerebrum*, yet at least equal thereto*.

Another convenience in this position of the *cerebrum* and *cerebellum*, the last ingenious anatomist (*d*) tells us is this: “ In the head of man,” saith he, “ the base of the *brain* and *cerebell*, yea,
 “ of

(*d*) *Willis Cereb. Anat. paulo post. In capite humano cerebri & cerebelli, &c.*

* It has been observed, that in all animals the vigour of mind has some relation to the quantity of brain, and to the perfection of its organization; and that the acuteness of the different senses is generally proportioned to the quantity of nerve bestowed on their organs. Man has a greater proportion of brain than any other animal; but many animals have a much greater proportion of nerve bestowed on different organs of sense. Many animals have therefore acuter senses than man; but man has a greater vigour of mind than any other animal on this globe. The brain of quadrupeds is somewhat similar to that of man, but proportionably smaller, and not perhaps so well organised. The brain of birds is seemingly the reverse of the human brain; the cortical substance is the interior, and the ventricles are situated in the white part on the outside. In the brain of birds there are no circumvolutions like the intestines, no *fornix*, no *corpus callosum*, nor *corpora striata*. The brain of fishes is in many respects similar to that of birds. It is very small in proportion to their body, and is generally surrounded with an oily matter. The two senses of seeing and hearing in many fishes are often very acute. The reptile tribes have very little brain, and like the fishes have no ganglions upon their nerves. Most insects have no brains at all, but a nervous cord that is full of ganglions that runs from one extremity to the other, and is denominated the spinal marrow. Swammerdam found in a species of snail, a brain with two lobes, in contact with the stomach, moveable by muscles, and without a fixed place in the body. See *Encyclop. Britan. Art. Physiology*. EDITOR.†

“ of the whole skull, is set parallel to the horizon ;
 “ by which means there is the less danger of the
 “ two brains joggling, or slipping out of their place.
 “ But in *quadrupeds*, whose head hangs down, the
 “ base of the skull makes a right angle with the
 “ horizon, by which means the brain is under-
 “ most, and the *cerebell* uppermost ; so that one
 “ would be apt to imagine the *cerebell* should not
 “ be steady, but joggle out of its place.” To re-
 medy which inconvenience he tells us, “ And lest
 “ the frequent concussions of the *cerebell* should
 “ cause a fainting, or disorderly motion of the
 “ spirits about the *præcordia*, therefore, by the ar-
 “ tifice of Nature, sufficient provision is made in all
 “ by the *dura meninx* closely encompassing the *cere-*
 “ *bellum* ; besides which, it is (in some) guarded
 “ with a strong bony fence ; and in others, as the
 “ hare, the coney, and such lesser *quadrupeds*, a part
 “ of the *cerebell* is on each side fenced with the
 “ *os petrosum* : so that by this double stay, its whole
 “ mass is firmly contained within the skull.”

Besides these peculiarities, I might take notice
 of divers other things no less remarkable, as the
nictitating membrane of the eye (*e*), the different
 passages of the *carotid arteries* (*f*) through the
 skull,

(*e*) See book iv. chap. 2. note (*kk*).

(*f*) *Arteria carotis aliquanto posterius in homine quàm in alio
 quovis animali, calvariam ingreditur, scil. juxta illud foramen, per
 quod sinus lateralis in venam jugularem desiturus cranio elabitur ;
 nam in cæteris hæc arteria sub extremitate, seu processu acuto ossis pe-
 trosi, inter cranium emergit : verùm in capite humano, eadem, am-
 lage*

skull, their branching into the *rete mirabile* (g), the different magnitude of the *nates*, and some other parts

bage longiori circumducta (ut sanguinis torrens, priusquam ad cerebri oram appellit, fracto impetu, lenius & placidius fluat) prope specum ab ingressu sinûs lateralis factum, calvariae basin attingit;—& in majorem cautelam, tunicâ insuper ascititiâ crassiore investitur.—

“The carotid artery enters the skull a little farther back in man than in any other animal, viz. close by that opening from whence issues the lateral sinus that terminates in the jugular vein: for in other animals this artery enters the skull towards the extremity or acute process of the *os petrosum*; but in the human head, this artery making a longer circuit (that the current of the blood may have its force somewhat broken, and flow more smoothly and gently), reaches the under-part of the skull, near that cavity made by the entry of the lateral sinus—and that it may be the better protected, it is covered with an additional and thicker coat.”—And so he goes on to shew the conveniency of this guard the artery hath, and its passage to the brain; and then saith, *Si hujusmodi conformationis ratio inquiritur, facile occurrit, in capite humano, ubi generosi affectus & magni animorum impetus ac ardores excitantur, sanguinis in cerebri oras appulsum debere esse liberum & expeditum, &c. Atque hoc quidem respectu differt homo à plerisque brutis, quibus, arteria in mille furculos divisa, ne sanguinem pleniore alveo, aut citatiore, quàm par est, cursu, ad cerebrum evehat, plexus retiformes constituit, quibus nempe efficitur, ut sanguis tardo admodum, lenique & æquabili fere stillicidio, in cerebrum illabatur.—*“If a reason is asked for this peculiar conformation, it is evidently this; that in the human head which is the seat of the nobler feelings, and where there is often a great excitation of the animal spirits, the passage of the blood to the brain ought to be free and unincumbered. And in this respect man differs from most of the brute animals, in which we observe that this artery is divided into numberless small branches, that the blood may not be conveyed in a fuller stream, or more quickly than is convenient, to the brain; and it forms the *plexus retiformes*, by means of which the blood is conveyed slowly, equally,

parts of the brain in beasts, quite different from what it is in man : but the touches already given, may be instances sufficient to prevent my being tedious in enlarging upon these admirable works of God.

and almost by drops, into the brain."—And then he goes on to give a farther account of this artery, and the *rete mirabile* in divers creatures. *Willis, Cereb. Anat.* c. 8.

(g) *Galen* thinks the *rete mirabile* is for concocting and elaborating the animal spirits, as the *Epididymedes* [the convolutions *κισσοειδῆς ἑλμαί*] are for elaborating the feed. *De Uf. Part.* l. 9. c. 4. This *rete* is much more conspicuous in beasts than man ; and, as Dr. *Willis* well judges, serves, 1. To bridle the too rapid incursions of the blood into the brain of those creatures, whose heads hang down much. 2. To separate some of the superfluous ferous parts of the blood, and send them to the salival glands, before the blood enters the brain of those animals, whose blood is naturally of a watery constitution. 3. To obviate any obstructions that may happen in the arteries, by giving a free passage through other vessels, when some are stopped.

In *quadrupeds*, as the *carotid arteries* are branched into the *rete mirabile*, for the bridling the too rapid current of blood into the brain ; so the *vertebral arteries* are, near their entrance into the skull, bent into an acuter angle than in man, which is a wise provision for the same purpose.

C H A P. III.

Of the Necks of Quadrupeds.

FROM the head pass we to the neck, no principal part of the body, but yet a good instance of the Creator's wisdom and design, inasmuch as in man it is short, agreeable to the erection of his body; but in the four-footed tribe it is long, answerable to the length of the legs (*a*), and in some
of

(*a*) It is very remarkable, that in all the species of *quadrupeds*, this equality holds, except only the *elephant*; and that there should be a sufficient special provision made for that creature, by its *proboscis* or *trunk*:—a member so admirably contrived, so curiously wrought, and with so great agility and readiness, applied by that unwieldy creature to all its several occasions, that I take it to be a manifest instance of the Creator's workmanship. See its anatomy in Dr. *A. Moulen's Anat. of the Elephant*, p. 33. As also in Mr. *Blair's* account in *Phil. Transf.* No. 326.*

Aliorum

* As the books here referred to by Mr. Derham are not in everybody's hands, it may not be improper to give a short description both of the form and uses of this extraordinary instrument, which to the elephant answers all the purposes of the human hand. The elephant excels all other animals, perhaps even man himself, in the sense of touching. This sense resides entirely in his trunk; which is a fleshy tube composed of muscles and nerves, and covered with a skin of a blackish colour, like that of the rest of the body. It is hollow, with a double perforation running from one end to the other, and ending in two openings

of these long, and less strong, serving to carry the mouth to the ground; in others shorter, brawny and

Aliorum ea est humilitas ut cibum terrestrem rostris faciliè contingant. Quæ autem altiora sunt, ut anseres, ut cygni, ut grues, ut camelæ, adjuvantur proceritate collorum. Manus etiam data elephantis, qui propter magnitudinem corporis difficiles aditus habebant ad pastum.

—"Some animals are so low that they can easily take their food from the earth, by means of their beak or muzzle. Those which are higher, as geese, swans, and cranes, are aided by the length of their necks. The elephant is furnished with a trunk, because from its immense bulk it would otherwise find it difficult to seek its food."—*Cic. de N. D. l. 2. c. 47.*

Quod iis animalibus quæ pedes habent fissos in digitos, collum brevius sit factum, quàm ut per ipsum cibum ori admoveere queant: iis verò quæ ungulas habent solidas, aut bifidas, longius, ut prona atque inclinantia pasci queant. Qui id etiam opus non sit artificis utilitatis memoris? Ad hæc quòd grues ac ciconiæ, cum crura haberent longiora, ob eam causam rostrum etiam magnum, & collum longius habuerint.

Pisces

or nostrils, like those of a hog. An elephant of fourteen feet high, has a trunk about eight feet in length, and five feet and a half in circumference at its thickest part next the head. It is extremely flexible, capable of being moved in every direction, and of being bent or straightened at pleasure, so as to embrace closely any object to which it is applied, and endowed with such prodigious muscular strength, that the animal can tear a moderate sized tree up by the roots; and twist off and shatter with it the largest branches. On the underside it is furnished with little protuberances like the feet of a caterpillar, by means of which it lays the faster hold of the objects which it grasps; and at the point just above the nostrils is an extension of the skin about five inches long, in the form of a finger, with which it can lay hold of the minutest objects. By means of this singular conformation, this animal can pick up a pin from the ground, untie the knots of a rope, unlock a door, and even write with a pen.

Ælian

and strong, serving to dig, and heave up great burdens (b).

But that which deserves especial remark, is that peculiar provision made in the necks of all, or most granivorous *quadrupeds*, for the perpetual holding down their head in gathering their food, by that strong tendinous and insensible *aponeurosis* or ligament

Pisces autem neque collum penitus habuere, utpote qui neque crura habent. Quo pacto non id etiam est admirandum? — “Those animals whose feet are divided by toes, have a shorter neck, because by means of them they can bring their food to their mouth; but such as have solid hoofs, or are cloven-footed, have their necks longer, that they may be able to feed by bending or inclining downwards. How can this be otherwise than the work of an artificer ever mindful of utility? Moreover cranes, and storks, having very long legs, are on that account furnished likewise with long necks and great bills. Fishes have no necks at all, because they have no legs. How admirably is all this contrived?” — *Galen de Uf. Part. l. 11. c. 8.*

(b) As in *moles* and *swine*, in c. 2. note (a).

Ælian says, that he has seen an elephant who wrote Latin characters on a board from a copy pointed out by his keeper. Through this trunk the animal breathes and smells; but does not drink as some authors have erroneously said. He lifts the water, or sucks it up into his trunk, where, by drawing in his breath he keeps it suspended till he twists the end of the proboscis dextrously into his mouth, which lies immediately under it, and therein empties the water. When feeding on grass, which is its natural food, on hay, or straw, it does not take these substances directly into the mouth, but laying hold of them first with the trunk, coils them very dextrously into round balls or clews, and then puts them one by one into the mouth.

ment (c) braced from the head to the middle of the back. By which means the head, although heavy, may be long held down without any labour, pain, or uneasiness to the muscles of the neck, that would otherwise be wearied by being so long put upon the stretch.

(c) Called the *Whitelcather*, *Packwax*, *Taxwax*, and *Fix-fax*.

C H A P. IV.

Of the Stomachs of Quadrupeds.

FROM the neck, let us descend to the *stomach*, a part as of absolute necessity to the being and well-being of animals, so is it in the several species of *quadrupeds*, sized, contrived, and made with the utmost variety and art (*a*). What artist, what being, but the infinite Conservator of the world, could so well adapt every food to all the several kinds of those grand devourers of it! Who could so well suit their stomachs to the reception and digestion thereof; one kind of stomach to the carnivorous, another to the herbaceous animals; one fitted to digest by bare mastication; and a whole set of stomachs in others, to digest with the help of *Rumination*! which last act, together with the *apparatus*

(*a*) The peculiar contrivance and make of the *dromedary's* or *camel's* stomach, is very remarkable, which I will give from the *Parisian anatomists*: *At the top of the second* [of the four ventricles] *there were several square holes, which were the orifices of about thirty cavities, made like sacks placed between the two membranes, which do compose the substance of this ventricle. The view of these sacks made us to think that they might well be the reservoirs, where Pliny saith, that camels do a long time keep the water, which they drink in great abundance—to supply the wants thereof in the dry deserts, &c. Vide Memoirs, &c. Anat. of Dromedary, p. 39. See also Peyer, Merycol. l. 2. c. 3.*

paratus for that service, is so peculiar, and withal so curious an artifice of nature, that it might justly deserve a more particular enquiry; but having formerly mentioned it (*b*), and lest I should be too tedious, I shall pass it by.

(*b*) *Book iv. chap. 11.*

C H A P. V.

Of the Hearts of Quadrupeds.

IN this part there is a notable difference found between the heart of man and that of beasts, concerning the latter, of which I might take notice of the remarkable conformation of the hearts of amphibious *quadrupeds*, and their difference from those of land-animals *, some having but one ven-
 tricle

* The modes of circulation are very curious in different animals. In some animals the heart throws its blood to the remotest parts of the system; in others it throws its blood only into the respiratory organs; from these it is collected by the branches of veins, and these branches uniting in a trunk, convey it to an artery, which renews the impulse, and acts as a heart. In a third set of animals the blood from the respiratory organs is carried by the veins to another heart; and this second heart, united in the same capsule with the first, distributes the blood by the channel of its arteries to the several parts. In the human fœtus, and the fœtus of those animals which have two hearts, a part of the blood, without taking the passage through the lungs, proceeds directly from auricle to auricle. In amphibious animals the auricular passage continues open during their life, and is employed when the breathing ceases under the water. In many insects a number of hearts or expansions, which answer the purpose of hearts, are placed at intervals on the circulating course, and each renews the impulse of the former, where the momentum of the blood fails. In the *sepia loligo*, the two separate parts of the gills are each supplied by a heart of its own: the blood

tricle (*a*), some three (*b*), and some but two, (like land-animals,) but then the *foramen ovale* therewith (*c*). All which may be justly esteemed as wonderful, as they are excellent provisions for the manner of those animals living. But I shall content myself with bare hints of these things, and speak only of two peculiars more, and that but briefly.

One

(*a*) *Frogs* are generally thought to have but one ventricle in their hearts.

(*b*) The *tortoise* hath three ventricles, as the *Parisian academists* in their *memoirs* affirm. Besides these two ventricles [before spoken of] which were in the hinder part of the heart, which faceth the spine; there was, say they, a third in the forepart, inclining a little towards the right side, &c. *Memoirs*, &c. p. 259. But Mr. *Buffiere* charges this as a mistake in those ingenious gentlemen, and asserts there is but one ventricle in the *tortoise's* heart. See his description of the heart of the *land-tortoise*, in *Philosoph. Transact.* No. 328.

(*c*) The *sea-calf* is said by the *French academists* to have this provision, and their account of it is this: Its heart was round and flat. Its ventricles appeared very large, and its auricles small. Underneath the great aperture, through which the trunk of the vena cava conveyed the blood into the right ventricle of the heart, there was another, which penetrated into the arteria venosa, and from thence into the left ventricle, and afterwards into the aorta. This hole, called the *foramen ovale* in the foetus, makes the anastomosis, by the means of which the blood goes from the cava into the aorta, without passing through the lungs. *French Anatomists*, p. 124.

blood from both is collected into one; which by two arteries opening at two different parts, send it at once to the opposite extremities. In numbers of animals the heart, like the stomach, is in the extremity opposite to the head. See *Encyclop. Brit. Art. Physiology*.

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One is the situation of the heart, which in beasts is near the middle of the whole body; in man, nearer the head (*d*). The reasons of which I shall give from one of the most curious anatomists (of that part (*e*)). “Seeing,” saith he, “the tra-
 “jection and distribution of the blood depends
 “wholly on the systole of the heart, and that its
 “liquor is not driven of its own nature so readily
 “into the upper parts as into vessels even with it,
 “or downwards into those under it: if the situa-
 “tion of the heart had been farther from the
 “head, it must needs either have been made
 “stronger to cast out its liquor with greater force;
 “or else the head would want its due proportion
 “of blood. But in animals that have a longer
 “neck, and which is extended towards their food
 “as it were, the heart is seated as far from the
 “other parts; and they find no inconvenience
 “from it, because they feed with their head for
 “the most part hanging down; and so the blood,
 “as it hath farther to go to their head than in
 “others, so it goes a plainer and often a steep
 “way (*f*).”

The

(*d*) Τὴν τε Καρδίαν περὶ τὸ μέσον πλὴν ἐν Ἀνθρώπῳ, &c.—“The heart is in the middle, except in man.”—*Arist. Hist. An.* l. 2, c. 17.

(*e*) Dr. Lower de Corde, c. 1.

(*f*) I might have mentioned another wise provision from the same author, which take in his own words: *In vitulis & equis, imò plerisque aliis animalibus majoribus, non solas propagines à nervo sexti paris ut in homine, sed etiam plurimas à nervo intercostali, ubi rectè cor transit, cor accedere, imò in parenchyma ejus dimitti: & hoc ideo à Naturâ*

The other peculiar matter is, the fastening (I formerly mentioned) which the cone of the *pericardium* hath in man to the *diaphragm* (g), whereas in all *quadrupeds* it is loose. By which means the motion of the *midriff*, in that necessary act of respiration, is assisted both in the upright posture of man, as also in the prone posture of *quadrupeds* (h), which

à Naturâ quasi subsidium brutis comparatum, ne capita que terram prona spectant, non satis faciliè aut copiosè spiritus animales impertirent.—"In cows and horses, and in most of the larger animals, not only the branches from the nerves of the sixth pair (as in the human body) but even several branches from the intercostal nerve come to the heart, and are diffused in its *parenchyma*; and this is given by Nature to animals as a subsidiary provision; lest their heads, which incline downwards, should not be sufficiently supplied with animal spirits."—*Blasii Anat. Animal. Par. 1. c. 4. ex Lowero, de Corde.*

(g) *Diaphragmatis circulo nerveo firmiter adheret* [pericardium] *quod homini singulare; nam ab eo in canibus & simiis distat, item in aliis animalibus omnibus.*—"The pericardium adheres firmly to the nervous circle of the diaphragm: and this is peculiar to man; for it is removed from it in dogs, apes, and indeed in all other animals."—*Bartholin. Anat. l. 2. c. 5.*

(h) *Finalem causam quod attinet,—cùm erectus sit hominis incessus atque figura, eoque faciliùs abdominis viscera suo pondere descendant, minore diaphragmatis nixu atque systole ad inspirationem opus est: porrò, cùm in expiratione pariter necessarium sit diaphragma relaxari, cùm capsula cordis omnino connedendum fuit, in homine, ne fortè, quamdiu erectus incedit, ab hepatis, aliorumque viscerum appensorum pondere deorsum adeò deprimeretur, ut neque pulmo satis concidere, neque exspiratio debito modo peragi potuerit. Quocirca in quadrupedibus, ubi abdominis viscera in ipsum diaphragma incumbunt, ipsumque in pectoris cavitatem suo pondere impellunt, ista partium accretio expirationi quidem inutilis, inspirationi autem debitam diaphragmatis tensionem impediendo, prorsus incommoda fuisset.*—"With regard to the final cause—as man is upright in his gait and figure, and the viscera

which would be hindered, or rendered more difficult, if the case was otherwise: “ Which must
 “ needs be the effect of wisdom and design, and
 “ that man was intended by Nature to walk erect,
 “ and not upon all-four, as *quadrupeds* do;” to
 express it in the words of a great judge in such
 matters (i).

viscera of the abdomen on that account descend by their own weight, there is less occasion for an effort and systole of the diaphragm for inspiration: moreover, as in expiration, it is necessary that the diaphragm should be relaxed, it was quite necessary that in the human body it should be connected with the capsula of the heart, lest while he is walking erect, it should be so depressed by the incumbent weight of the liver, and the other appended viscera, that the lungs could neither sufficiently collapse, nor expiration be duly and properly performed. For that reason, in quadrupeds, where the viscera of the abdomen lie upon the diaphragm itself, and impell it by their weight into the cavity of the breast, that connection or accretion of the parts is of no use to expiration, and would be very prejudicial to inspiration, by hindering the proper tension of the diaphragm.”—*Lower de Corde*, p. 8.

(i) Dr Tyson's *Anatomy of the orang-outang*, in Ray's *Wisdom of God*, p. 262.

C H A P. VI.

Of the Difference between Man and Quadrupeds in the Nervous Kind.

THERE is only one difference more between *man* and *quadrupeds* that I shall take notice of, and that is, the nervous kind: and because it would be tedious to insist upon many particulars (*a*), I shall, for a sample, insist chiefly upon one, and that is, of Nature's prodigious care for a due communication and correspondence between the head and heart of man, more than what is in the four-footed tribe. For this purpose, besides the correspondence those parts have by means of the nerves of the *par vagum*, (common both to man and beast,) there is a farther and more special communication and correspondence occasioned by the branches (*b*) of the *intercostal*

(*a*) Amongst these, I might name the site of the nerves proceeding from the *medulla spinalis*, which Dr. Lower takes notice of. In beasts, whose spine is above the rest of the body, the nerves tend directly downwards; but in man, it being erect, the nerves spring out of the spine, not at right, but in oblique angles downwards, and pass also in the body the same way. Lower, de Corde, p. 16.

(*b*) *In plerisque brutis tantum hac via (i. e. by the par vagum) & vix omnino per ullos paris intercostalis nervos, aditus ad cor aut appendicem ejus patefcit. Verum in homine, nervus intercostalis, præter officia ejus in imo ventre huic cum cæteris animalibus communia etiam ante pectoris claustra internuncii specialis loco est, qui cerebri & cordis*

costal pair sent from the *cervical plexus* to the heart and *præcordia*. By which means the heart and brain of man have a mutual and very intimate correspondence and concern with each other, more than is in other creatures; or as one of the most curious anatomists and observers of these things saith (c): “Brutes are as it were machines made
 “with a simpler, and less operose *apparatus*, and
 “endowed therefore with only one and the same
 “kind of motion, or determined to do the same
 “thing: whereas in man, there is a great variety
 “of motions and actions. For by the commerce
 “of the aforesaid *cervical plexus* (d),” he saith,
 “the

Et cordis sensa mutua altra citraque refert.—“In most brutes there is no communication with the heart or its appendices, but by the *par vagum*, and scarcely at all by any of the nerves of the intercostal pair. But in man, the intercostal nerve, besides its functions in the lower belly, which are likewise common to other animals, is, as it were, a special messenger in the cavity of the breast, to communicate and distribute the mutual sensations of the brain and heart.”—*Willis Nervor. Descr. & Usus*, c. 26.

(c) Id. ib. *Dum hanc utriusque speciei differentiam perpendo, succurrit animo, bruta esse velut machinas, &c.*—“When I consider the difference of the two species, I look upon brutes as it were machines,” &c.

(d) That our great man was not mistaken, there is great reason to imagine, from what he observed in dissecting a fool. Besides, the brain being but small, he saith, *Præcipua autem discriminis nota quam inter illius & viri cordati partes advertimus, hæcce erat; nempe quòd prædictus nervi intercostalis plexus, quem cerebri & cordis internuncium & hominis proprium diximus, in stulto hoc valde exilis, & minori nervorum satellitio stipatus fuerit.*—“The chief mark of difference which I observed between

“ the conceptions of the brain presently affect the
 “ heart, and agitate its vessels and whole appen-
 “ dage, together with the *diaphragm*. From
 “ whence the alteration in the motion of the
 “ blood, the pulse, and respiration. So also on
 “ the contrary, when any thing affects or alters the
 “ heart, those impressions are not only retorted to
 “ the brain by the same duct of the nerves, but
 “ also the blood itself (its course being once
 “ changed) flies to the brain with a different and
 “ unusual course, and there agitating the animal
 “ spirits with divers impulses, produceth various
 “ conceptions and thoughts in the mind.” And he
 tell us, “ That hence it was that the ancient di-
 “ vines and philosophers too, made the heart the
 “ feat of wisdom: and certainly (saith he) the
 “ works of wisdom and virtue do very much de-
 “ pend upon this commerce which is between the
 “ heart and brain:” And so he goeth on with
 more to the same purpose. Upon the account
 of this *intercostal commerce* with the heart, being
 wanting in brutes, there is another singularly care-
 ful and wise provision the infinite Creator hath
 made in them, and that is, that by reason both
 the *par vagum*, and the *intercostal* too, do not send
 their

the parts of this ideot and those of a man of sound understand-
 ing was, that the plexus of the intercostal nerve above described,
 as peculiar to man, and which we have termed the messenger be-
 tween the brain and heart, was in the ideot very small, and fur-
 nished with a much less appendage of nerves.”—*Willis Nervor.*
Descr. & Usus, c. 26.

their branches to the heart, and its appendage in brutes; therefore, lest their heart should want a due proportion of nervous vessels, the *par vagum* sends more branches to their heart than to that of man. This, as it is a remarkable difference between rational and irrational creatures; so it is as remarkable an argument of the Creator's art and care; who although he hath denied brute-animals reason, and the nerves ministring thereto, yet hath another way supplied what is necessary to their life and state. But let us hear the same great author's descant upon the point (*e*): "Inasmuch," saith he, "as beasts are void of discretion, and but little
 " subject to various and different passions, therefore
 " there was no need that the spirits, that were to
 " be conveyed from the brain to the *præcordia*,
 " should pass two different ways, namely, one for
 " the service of the vital functions, and another
 " for the reciprocal impressions of the affections;
 " but it was sufficient that all their spirits, what-
 " ever use they were designed for, should be con-
 " veyed one and the same way."

Here now in the *nervous kind* we have manifest acts of the Creator's design and wisdom, in this so manifest and distinct a provision for rational and irrational creatures; and that *man* was evidently intended to be the one, as the *genus* of *quadrupeds* was the other.

(*e*) *Willis Nervor. Deffer. & Usus*, cap. 29. *In quantum bestia prudentiâ carent, & variis diversisque passionibus, &c.*—"Inasmuch as beasts are void of prudence and of various passions," &c.

C H A P. VII.

The Conclusion.

AND now it is time to pause a while, and reflect upon the whole. And as from the considerations in the preceding Book, we have especial reason to be thankful to our infinitely merciful Maker, for his no less kind than wonderful contrivances of our body; so we have reason, from this brief view I have taken of this last tribe of the creation, to acknowledge and admire the same Creator's work and contrivances in them. For we have here a large family of animals, in every particular respect, curiously contrived and made, for that especial posture, place, food, and office or business which they obtain in the world. So that if we consider their own particular happiness and good, or man's use and service; or if we view them throughout, and consider the parts wherein they agree with man, or those especially wherein they differ, we shall find all to be so far from being things fortuitous, undesigned, or any way accidental, that every thing is done for the best; all wisely contrived, and incomparably fitted up, and every way worthy of the great Creator. And he that will shut his eyes, and not see God (a) in

(a) ——— *Deum namque ire per omnes
Terrasque tractusque maris, cælumque profundum.
Hinc pecudes, armenta, viros, genus omne ferarum.*

“ For

in these his works, even of the poor beasts of the earth, that will not say, (as *Elibu* hath it, *Job xxxv. 10, 11.*) *Where is God my Maker, who teacheth us more than the beasts of the earth, and maketh us wiser than the fowls of the Heaven?* Of such an one we may use the psalmist's expression, *Psal. xlix. 12.* That *he is like the beasts (b) that perish.*

“ For God pervades the whole, both earth and air
And ocean's bounds ; and hence all nature lives
And teems with various forms of man, of beast,
Of fowl, and creeping thing.” VIRGIL. *Georg.* lib. iv.

(b) *Illos qui nullum omnino Deum esse dixerunt, non modò non philosophos, sed ne homines quidem fuisse dixerim ; qui, mutis simillimi, ex solo corpore constiterunt, nihil videntes animo.*—“ Those who deny that there is a God, so far from esteeming them to be philosophers, I cannot even account them men ; for they resemble the dumb brutes, who see nothing by the mind, but are affected only through the medium of their senses.—*Lactant.* l. 7. c. 9.

B O O K VII.

A Survey of Birds.

HAVING briefly, as well as I could, dispatched the tribe of *quadrupeds* ; I shall next take as brief and transient a view of the *feathered tribe*.

And here we have another large province to expatiate in, if we should descend to every thing wherein the workmanship of the Almighty appears. But I must contract my *survey* as much as may be ; and shall therefore give only such hints and touches upon this curious family of animals, as may serve for samples of the rest of what might be observed.

CHAP. I.

Of the Motion of Birds, and the Parts ministering thereto.

AS this tribe hath a different motion from that of other animals, and an amphibious way of life; partly in the air, and partly on the land and waters; so is their body accordingly shaped, and all their parts incomparably fitted for that way of life and motion; as will be found by a cursory view of some of the particulars. And the

I. And most visible thing, is the shape and make of their body, not thick and clumsy, but incomparably adapted to their flight: sharp before, to pierce and make way through the air, and then by gentle degrees rising to its full bulk. To which we may add,

II. The neat position of the *feathers* throughout the body; not ruffled, or discomposed, or placed some this, some a contrary way, according to the method of chance; but all artificially placed (*a*), for facilitating the motion of the body, and its security at the same time, by way of clothing: and for that end, most of the feathers tend backward, and are laid over one another in exact and regular method, armed with warm and soft down next the body,

(*a*) See before *book iv, chap. 12. note (1)*.

body, and more strongly made, and curiously closed next the air and weather, to fence off the injuries thereof. To which purpose, as also for the more easy and nimble gliding of the body through the air, the provision Nature hath made, and the instinct of these animals to *preen* and *dress* their feathers, is admirable; both in respect of their art and curiosity in doing, and the *oil-bag* (*b*), glands, and whole apparatus for that service.

III. And now having said thus much relating to the body's motion, let us survey the grand instrument thereof, the *wings*. Which as they are principal parts, so are made with great skill, and placed in the most commodious point of the body (*c*), to give

(*b*) Mr. *Willughby* saith, there are two glands for the secretion of the unctuous matter in the *oil-bag*. And so they appear to be in geese. But upon examination, I find, that in most other birds, (such at least as I have inquired into,) there is only one gland; in which are divers little cells, ending in two or three larger cells, lying under the nipple of the *oil-bag*. This *nipple* is perforated, and being pressed, or drawn by the bird's bill, or head, emits the liquid oil, as it is in some birds, or thicker unctuous grease, as it is in others. The whole *oil-bag* is in its structure somewhat conformable to the breasts of such animals as afford milk.

(*c*) In all birds that fly much, or that have the most occasion for their wings, it is manifest that their wings are placed in the very best part, to balance their body in the air, and to give as swift a progression, as their wings and body are capable of: for otherwise we should perceive them to reel, and fly unsteadily; as we see them to do, if we alter their equipoise, by cutting the end of one of their wings, or hanging a weight at any of the extreme parts of the body. But as for such birds as have as

give it an exact equipoise in that subtile medium, the air.

And here it is observable, with what incomparable curiosity every feather is made; the *shaft* exceeding strong, but hollow below, for strength and lightness sake; and above, not much less strong, and filled with a *parenchyma* or *pith*, both strong and light too. The *vanes* as nicely gauged on each side as made; broad on one side, and narrower on the other; both which incomparably minister to the progressive motion of the bird, as also to the union and closeness of the wing (*d*).

And

much occasion for swimming as flying, and whose wings are therefore set a little out of the centre of the bodies gravity, see *book* iv. *chap.* 8. *note* (*q*); and for such as have more occasion for diving than flying, and whose legs are, for that reason, set more backward, and their wings more forward, *chap.* 4. *note* (*k*) of this *book*.

(*d*) The wise Author of Nature hath afforded an example of the great nicety in the formation of birds, by the nicety observed in a part no more considerable than the vanes of the flag-feathers of the wing. Among others, these two things are observable: 1. The edges of the exterior or narrow vanes bend downwards, but of the interior wider vanes upwards; by which means they catch, hold, and lie close to one another, when the wing is spread; so that not one feather may miss its full force and impulse upon the air. 2. A yet lesser nicety is observed, and that is, in the very sloping the tips of the flag-feathers: the interior vanes being neatly sloped away to a point, towards the outward part of the wing; and the exterior vanes sloped towards the body, at least in many birds; and in the middle of the wing, the vanes being equal, are but little sloped. So that the wing, whether extended or shut, is as neatly sloped and formed, as if constantly trimmed with a pair of scissars.

And no less exquisite is the textrine art of the *plumage* (e) also; which is so curiously wrought, and so artificially interwoven, that it cannot be viewed without admiration, especially when the eye is assisted with glasses.

And

(e) Since no exact account, that I know of, hath been given of the mechanism of the *vanes*, or *webs* of the feathers, my observations may not be unacceptable. The *vane* consists not of one continued membrane; because if once broken, it would hardly be reparable: but of many *laminae*, which are thin, stiff, and somewhat of the nature of a thin quill. Towards the shaft of the feather, (especially in the flag-feathers of the wing,) those *laminae* are broad, &c. of a semicircular form; which serve for strength, and for the closer shutting of the *laminae* to one another, when impulses are made upon the air. Towards the outward part of the vane, these *laminae* grow slender and taper: on their under side they are thin and smooth, but their upper-outer edge is parted into two hairy edges, each side having a different sort of hairs, laminated or broad at bottom, and slender and bearded above the other half. I have, as well as I could, represented the uppermost edge of one of these *laminae* in Plate H, *fig. 9* with some of the hairs on each side, magnified with a microscope. These bearded bristles, or hairs, on one side the *laminae*, have strait beards, as in *fig. 10*. those on the other side, have hooked beards on one side the slender part of the bristle, and strait ones on the other, as in *fig. 11*. Both these sorts of bristles magnified, (only scattering, and not close,) are represented as they grow upon the upper edge of the *lamina* *f. t.* in *fig. 9*. And in the vane, the hooked beards of one *lamina*, always lie next the strait beards of the next *lamina*; and by that means lock and hold each other: and by a pretty mechanism, brace the *laminae* close to one another. And if at any time the vane happens to be ruffled and discomposed, it can by this pretty easy mechanism, be reduced and repaired. Vide *book iv. chap. 12. note (m)*.

And as curiously made, so no less curiously are the feathers placed in the wing, exactly according to their several lengths and strength: the *principals* set for stay and strength, and these again well lined, faced, and guarded with the *covert* and *secondary feathers*, to keep the air from passing through, whereby the stronger impulses are made thereupon.

And lastly, to say no more of this part, that deserves more to be said of it, what an admirable *apparatus* is there of *bones*, very strong, but withal light and incomparably wrought? of *joints*, which open, shut, and every way move, according to the occasions either of extending it in flight, or withdrawing the wing again to the body? and of various *muscles*; among which the peculiar strength of the *pectoral muscles* deserves especial remark, by reason they are much stronger (*f*) in birds than in man, or any other animal, not made for flying?

IV. Next

(*f*) *Pectorales musculi hominis flectentes humeros, parvi & parum carnosissimi sunt; non æquant quinquagesimam aut septuagesimam partem omnium musculorum hominis. E contra in avibus, pectorales musculi vastissimi sunt, & æquant, imò excedunt, & magis pendent, quam reliqui omnes musculi ejusdem avis simul sumpti.*—"The pectoral muscles in man, which bend the shoulders, are small, and not at all fleshy: they do not equal the 50th or 70th part of all the muscles of the human body. But on the other hand, in birds the pectoral muscles are very large, and equal, nay exceed, in size and in weight, all the other muscles of the animal taken together."—*Borell. de Mot. Animal. vol. i. prop. 184.*

Mr. Willughby having made the like observation, hath this reflection on it, whence, if it be possible for man to fly, it is thought

IV. Next the wings the tail is in flight considerable, greatly assisting in all ascents and descents in the air, as also serving to steady (g) flight, by keeping the body upright in that subtle and yielding *medium*, by its readily turning and answering every vacillation of the body.

And now to the parts serving to flight, let us add the nice and complete manner of its performance, all done according to the strictest rules of mechanism (b). What rower on the waters, what artist on the land, what acutest mathematician could give a more agreeable and exact motion to the wings than these untaught flying artists do theirs! serving not only to bear their bodies up in the air, but also to waft them along therein with a speedy progressive motion, as also to steer and turn them this way and that way, up and down, faster or slower as their occasions require, or their pleasure leads them.

V. Next

by them who have curiously weighed and considered the matter, that he that would attempt such a thing with hopes of success must so contrive and adapt his wings, that he may make use of his legs, and not his arms in managing them (because the muscles of the legs are stronger as he observes). Willugh. Ornith. l. I. c. I. sect. 19.

(g) Mr. Willughby, Ray, and many others imagine the principal use of the tail to be to steer and turn the body in the air as a rudder. But Borelli hath put it beyond all doubt, that this is the least use of it, and that it is chiefly to assist the bird in its ascents and descents in the air, and to obviate the vacillations of the body and wings. For as for turning to this or that side, it is performed by the wings and inclination of the body, and but very little by the help of the tail.

(b) See Borelli *ubi supr.* prop. 182, &c.

V. Next to the parts for flight, let us view the *feet* and *legs* ministring to their other motion: both made light for either transportation through the air; and the former spread, some with membranes for swimming (*i*), some without, for steady going; for perching, for catching and holding of prey (*k*), or for hanging by the heels to gather their food (*l*), or to fix themselves in their places of

(*i*) It is considerable in all water-fowl how exactly their legs and feet correspond to that way of life. For either their legs are long to enable them to wade in the waters. In which case, their legs are bare of feathers a good way above the knees, the more conveniently for this purpose. Their toes also are all broad; and in such as bear the name of *mudfuckers*, two of the toes are somewhat joined, that they may not easily sink in walking upon boggy places. And as for such as are whole-footed, or whose toes are webbed together, (excepting some few,) their legs are generally short, which is the most convenient size for swimming. And it is pretty enough to see how artificially they gather up their toes and feet when they withdraw their legs, or go to take their stroke; and as artificially again extend or open their whole foot when they press upon or drive themselves forward in the waters.

(*k*) Some of the characteristics of rapacious birds are *to have hooked, strong, and sharp-pointed beaks and talons, fitted for rapine and tearing of flesh, and strong and brawny thighs for striking down their prey.* Willughby Ornith. l. 2. c. 1. Raii Synops. Av. Method. p. 1.

(*l*) Such birds as climb, particularly those of the *wood-pecker* kind, have for this purpose (as Mr. Willughby observes, l. 2. c. 4.) 1. Strong and musculous thighs. 2. Short legs and very strong. 3. Toes standing two forwards and two backwards. Their toes also are close joined together, that they may more strongly and firmly lay hold on the tree they climb upon.

of retreat and safety. And the latter, namely the *legs*, all curved for their easy perching, roosting, and rest, as also to help them upon their wings in taking their flight, and to be therein commodiously tucked up to the body, so as not to obstruct their flight. In some long, for wading and searching the waters; in some of a moderate length answerable to their vulgar occasions; and in others as remarkably short to answer their especial occasions and manner of life (*m*). To all these let us add the placing these last mentioned parts in the body. In all somewhat out of the center of the body's gravity,

upon. 4. All of them have a hard stiff tail bending also downwards on which they lean, and so bear up themselves in climbing.

(*m*) *Swifts* and *swallows* have remarkably short legs, especially the former, and their toes grasp any thing very strongly. All which is useful to them in building their nests, and other such occasions as necessitate them to hang frequently by their heels. But there is far greater use of this structure of their legs and feet, if the reports be true of their hanging by the heels in great clusters (after the manner of bees) in mines and grottos, and on the rocks by the sea all the winter. Of which latter, I remember the late learned Dr. *Fry* told this story at the university, and confirmed it to me since, *viz.* that an ancient fisherman, accounted an honest man, being near some rocks on the coast of *Cornwall*, saw at a very low ebb, a black list of something adhering to the rock, which when he came to examine, he found it was a great number of *swallows*, and, if I misremember not, of *swifts* also, hanging by the feet to one another as bees do, which were covered commonly by the sea waters; but revived in his warm hand, and by the fire. All this the fisherman himself assured the doctor of. Of this see more, *chap.* 3. *note* (*d*) of this book.

gravity (*n*), but in such as swim more than in others, for the better rowing their bodies through the waters, or to help them in that of diving (*o*) too.

(*n*) In birds that frequent not the waters, the wings are in the center of gravity when the bird lies along, as in flying; but when it stands or walks, the erection of the body throws the center of gravity upon the thighs and feet.

(*o*) See chap. 4. note (*k*).

C H A P. II.

Of the Head, Stomach, and other Parts of Birds.

THUS having dispatched the parts principally concerned in the motion of the *feathered tribe*, let us proceed to some other parts not yet animadverted upon. And we will begin with the *head*, concerning which I have already taken notice of its shape for making way through the air; of the make of the *bill* for gathering food, and other uses; the commodious situation of the *eye*; and I might add that of the *ear* too, which would be in the way and obstruct flight, if it was like that of most other animals; also I might say a great deal of the conformation of the *brain*, and of the parts therein wanting, and of others added, like to what is observable in fishes, whose posture in the waters resembles that of birds in the air (*a*), and

(*a*) *Cerebra hominum & quadrupedum in plerisque similia existunt.—Capitibus volucrum & piscium contenta, ab utrisque prioribus longè diversa, tamen inter se, quoad præcipuas & γυνεφύλακτες partes symbola reperiuntur.*—"The brains of man and of quadrupeds are in most particulars alike. In birds and fishes the contents of the head are very different from those of the former, yet have much resemblance between themselves in the principal parts." The particulars wherein the brains of birds and fishes agree with one another, and wherein they differ from the brain of man and beasts, see in the same justly famous author, *Willis Cereb. Anat. c. 5.*

and both very different from man and beasts; and lastly, to hint at no more, I might survey the peculiar structure of the *larynx* (b), the
tongue,

(b) *Circa bifurcationem asperæ arteriæ, elegans artificis liberè agentis indicium detegitur ex avium comparatione cum quadrupedibus: cum vocis gratia in diversis avibus diversam musculorum fabricam bifurcationi asperæ arteriæ dederit, quorum nullum vestigium extat in homine & quadrupedibus mihi visis, ubi omnes vocis musculos capiti arteriæ junxit. In aquilâ, &c. supra bifurcationem, &c.*—"Towards that part of the *aspera arteria* where it is split into two branches, an admirable and elegant proof is discovered of design and contrivance in the Artificer, by comparing the different structure of the parts in birds and in quadrupeds. For a different conformation of the muscles in this bifurcation of the artery is given to birds for the sake of their voice, from that which is to be observed in man and in quadrupeds, in which, so far as I have seen the muscles subservient to the voice, are all joined to the head of the artery *."—*Steno in Blasf. Anat. Animal. p. 2. c. 4.*

The

* In a very curious memoir by the Hon. Daines Barrington, in vol. lxiii. of the Philosophical Transactions, intitled *Experiments and Observations on the Singing of Birds*, the author relates, that from the dissections of Mr. Hunter, the celebrated anatomist, it appeared that the muscles of the larynx in singing birds was much stronger in the male birds than in the females; and that in the cock nightingale in particular their muscles were stronger than in any other bird of the same size. Another observation of the same writer deserves particular notice: "I believe," says he, "there is no instance of any birds singing which exceeds our blackbird in size; and possibly this may arise from the difficulty of concealing itself, if it called the attention of its enemies, not only by bulk but by the propor-

tongue (*c*), the inner ear (*d*), and many matters besides; but for a sample, I shall only insist upon the

The *aspera arteria* is very remarkable in the swan, which is thus described by T. Bartholin, viz. *Aspera arteria admirandæ satis structuræ. Nam pro colli longitudine deorsum œsophagi comes protenditur donec ad sternum perveniat, in cujus capsulam se incurvo flexu insinuat & recondit, velut in tuto loco & thecâ, moxque ad fundum ejusdem cavitatis delata sursum reflectitur, egrediturque angustias sterni, & claviculis mediis conscens, quibus ut fulcro nititur, ad thoracem se flectit.*—*Miranda hercle modis omnibus constitutio & respirationi inservit & voci. Nam cum in stagnorum fundo edulia pro victu querat, longissimo indiguit collo, ne longa mora suffocationis incurreret periculum. Et certè dum dimidiam fere horam toto capite & collo pronis vado immergitur, pedibus in altum elatis celoque obversis, ex eâ arteriæ quæ pectoris dictæ vaginæ reclusa est portione, tanquam ex condo promo spiritum haurit.*—"The *aspera arteria* is a very wonderful structure in the swan. For it extends downwards, and accompanies the œsophagus the whole length of the neck till it comes to the breast-bone, into the capsula of which it insinuates itself with an incurvated flexure, and is there concealed as in a safe case; thence reaching to the bottom of that cavity it is bent upwards and comes out between the narrow passage of the *sternum*, and middle clavicles, on which it rests as on a prop, and thence bends itself towards the *thorax*. This is a wonderful conformation, and is equally subservient to respiration and to the voice of the animal. For as it seeks its food in the bottom of lakes and pools, it requires
a very

tional loudness of its notes. I should rather conceive it is for the same reason that no hen-bird sings, because this talent would be still more dangerous during incubation; which may possibly also account for their inferiority in point of plumage."

the wonderful provision in the bill for the judging of the food, and that is by peculiar nerves lodged therein

a very long neck to prevent the hazard of suffocation while the head is under water. For as it remains sometimes half an hour with its head and neck entirely submerged, and its feet in an upright posture, it draws its breath by means of that portion of the artery which is included in the cavity of the breast, as from a magazine or storehouse."—*Blas. Anat. Animal.* p. 2. c. 10.

(c) The structure of the tongue of the wood-pecker is very singular and remarkable, whether we look at its great length, its bones and muscles, its encompassing part of the neck and head, the better to exert itself in length; and again, to retract it into its cell; and lastly, whether we look at its sharp, horny, bearded point, and the glewy matter at the end of it, the better to stab, to stick unto, and draw out little maggots out of wood. *Utilis enim picis (saith Coiter) ad vermiculos, formicas, aliaque insecta venanda talis lingua foret. Siquidem picus, innata sua sagacitate cum deprehendit alibi in arboribus, vel carie, vel alia de causa cavatis, vermes insectaque delitescere, ad illas volitat, seseque digitis, ungulisque posterioribus robustissimis, & caudæ pennis rigidissimis sustentat, donec valido ac peracuto rostro arborem pertundet: arbore pertusa, foramini rostrum immittit, ac quo animacula stridore excitet percussatque, magnam in arboris cavo emittit vocem, insecta vociferatione hæc concitata huc illucque repunt; picus v. linguam suam exerit, atque aculeis, hamisque animalia insigit, infixæ attrahit & devorat.*—"Such a tongue must be extremely useful to the wood-peckers in searching for worms, ants, and other insects. For whenever the wood-pecker apprehends, by its natural sagacity, that such insects are concealed in trees, hollowed by rottenness or any other cause, it immediately flies to them, and supporting itself by its strong hinder claws, and by the stiff feathers of its tail, it beats upon the tree with its beak, which is extremely strong and very sharp. This done, it thrusts its beak into the cavity, and in order to rouse and frighten the little animals, it makes a terrible noise in the hollow of the tree, and

therein for that purpose ; small and less numerous in such as have the assistance of another sense, the eye ;

and when the insects hurry about dreadfully alarmed by this vociferation, it thrusts out its long and pointed tongue, seizes them as with a hook, and draws them out and devours them." Vid. *Blasius*, ubi supra, p. 2. c. 24.

(d) I have before, in *book iv. chap. 3. note (u)*, taken notice of what others have observed concerning the *inner ear* of birds, reserving my own observations for this place ; which I hope may be acceptable, not only for being some of them new, but also shewing the mechanism of hearing in general.

In this organ of birds, I shall take notice only of three parts, the *membranes* and *cartilages*, the *columella*, and the *conclave*. The *drum*, as some call it, or *membrana tympani*, as others, consists of two membranes, the outer, which covers the whole *meatus*, *basin*, or *drum*, (as some call it,) and the inner membrane. To support, distend, and relax the outermost, there is one single cartilage, reaching from the side of the *meatus* to near the middle of the membrane. On the top of the *columella* is another cartilage, consisting of three branches, *a. b. c.* in Plate H, fig. 12. The longest middle branch *a.* is joined to the top of the single upper cartilage before spoken of, and assists it to bear up the upper outer membrane. The two branches *b. c.* are joined to the *os petrosum*, at some distance from the outer membrane : upon this inner cartilage is the inner membrane fixed, the two outer sides of which *a. b.* and *a. c.* are joined to the outer membrane, and make a kind of three-square bag. The design of the two branches or legs of the cartilage *b. c.* are, I conceive, to keep the cartilage and *columella* from wavering side-ways, and to hinder them from flying too much back. There is a very fine slender ligament extended from the opposite side, quite cross the *meatus* or *basin*, to the bottom of the *cartilage*, near its joining to the *columella*. Thus much for the *membrana tympani*, and their *cartilages*.

The next part is the *columella* (as *Schelhammer* calls it). This is a very fine, thin, light, bony tube ; the bottom of

eye; but large, more numerous, and thickly branched about to the very end of the beak, in such

which spreads about, and gives it the resemblance of a wooden pot-lid, such as I have seen in country-houses. It exactly shuts into and covers a *foramen* of the *conclave*, to which it is braced all round with a fine subtile membrane composed of the tender auditory nerve. This bottom or base of the *columella* I call the *operculum*.

The last part, which some call the *labyrinth* and *cochlea*, consisting of branches more like the *canales semicirculares* in man than the *cochlea*, I call the *conclave auditûs*. It is (as in most other animals) made of hard context bone. In most of the birds I have opened, there are *circular canals*, some larger, some lesser, crossing one another at right angles, which open into the *conclave*. But in the *goose* it is otherwise, there being cochleous canals, but not like those of other birds. In the *conclave*, at the side opposite to the *operculum*, the tender part of the *auditory nerve* enters, and lineth all those inner retired parts, *viz.* the *conclave* and *canals*.

As to the *passages*, *columnæ*, and other parts observable in the ear of birds, I shall pass them by, it being sufficient to my purpose to have described the parts principally concerned in the act of hearing. And as the ear is in birds the most simple and incomplex of any animal's ear, so we may from it make an easy and rational judgment how *hearing* is performed, *viz.* *sound* being a *tremor* or *undulation* in the air, caused by the collision of bodies, doth, as it moves along, strike upon the *drum*, or *membrana tympani* of the ear. Which motion, whether strong or languid, shrill or soft, tuneful or not, is at the same instant impressed upon the *cartilages*, *columella*, and *operculum*, and so communicated to the *auditory nerve* in the *conclave*.

And now if we compare the organ and act of hearing with those of sight, we shall find that the *conclave* is to hearing, as the *retina* is to sight; that sonorous bodies make their impressions thereby on the brain, as visible objects do by the *retina*. Also, that as there is an *apparatus* in the eye, by the opening
and

such as hunt for their food out of sight in the waters, in mud, or under ground (*e*).

And

and shutting of the pupil to make it correspond to all the degrees of light, so there is in the ear, to make it conformable to all the degrees of sound, a noble train of little bones and muscles in man, &c. to strain and relax the membrane, and at the same time to open and shut the *basis* of the *stapes* (the same as what I call the *operculum* in birds). But in birds there is a more simple, but sufficient *apparatus* for this purpose, tender cartilages, instead of bones and joints, to correspond to the various impressions of sounds, and to open and shut the *operculum*. Besides which, I suspect the ligament I mentioned is only the tendon of a muscle reaching to the inner *membrana tympani*, and joined thereto, (as I find by a stricter scrutiny,) and not to the cartilage as I imagined. By this muscle, the inner membrane, and by means of that the outer also, can be distended or relaxed, as it is in man, by the *malleus* and its muscle, &c.

(*e*) Flat-billed birds, that grope for their meat, have three pair of nerves that come into their bills, whereby they have that accuracy to distinguish what is proper for food, and what to be rejected by their taste, when they do not see it. This was most evident in a duck's bill and head; ducks having larger nerves that come into their bills than geese, or any other bird that I have seen; and therefore quaffer and grope out their meat the most. But then I discovered none of these nerves in round-billed birds. But since, in my anatomies in the country, in a rook, I first observed two nerves that came down betwixt the eyes into the upper bill, but considerably smaller than any of the three pair of nerves in the bills of ducks, but larger than the nerves in any other round-billed birds. And it is remarkable that these birds, more than any other round-billed birds, seem to grope for their meat in cow-dung, &c. Mr. J. Clayton in *Philos. Trans.* No. 206.

I observed three pair of nerves in all the broad-billed birds that I could meet with, and in all such as feel for their food out of sight, as snipes, woodcocks, curlews, geese, ducks, teals, widgeons, &c.

s 3 These

And now from the head and mouth pass we to its nearly the stomach, another no less notable than useful part; whether we consider the elegance of its fibres and muscles, or its multiplicity; one to soften and macerate, another to digest; or its variety suited to various foods, some membranous, agreeable to the frugivorous or carnivorous kind; some muscous and strong (*f*) suited to the comminution, and grinding of corn and grain, and so to supply the defect of teeth.

And now to this specimen of the parts, I might add many other things no less curiously contrived, made and suited to the occasions of these volatiles, as particularly the structure and lodgment of the
lungs,

These nerves are very large, equalling almost the optic nerve in thickness.—Two are distributed nigh the end of the upper bill, and are there very much expanded, passing through the bone into the membrane, lining the roof of the mouth. Dr. A. Moulen, ibid. No. 199. Or both in Mr. Lowthorp's Abridg. vol. ii. p. 861, 862.

(*f*) The gizzard is not only made very strong, especially in the granivorous, but hath also a faculty of grinding what is therein. For which purpose the bird swalloweth rough stones down, which when grown smooth are rejected and cast out of the stomach as useless. This grinding may be heard in falcons, eagles, &c. by laying the ear close to them when their stomachs are empty, as the famous Dr. Harvey saith. *De Generat. Exer. 7.*

As to the strength of the gizzard, and the use of stones to the digestion of fowls, divers curious experiments may be met with, tried by *Seigneur Redi* with glass bubbles, solid glass, diamonds, and other hard bodies. See his *Exp. Nat.*

lungs (g), the configuration of the *breast*, and its bone, made like a keel, for commodious passage through

(g) It is no less remarkable in birds, that their *lungs* adhere to the *thorax*, and have but little play, than that in other animals they are loose and play much, which is a good provision for their steady flight. Also they want the *diaphragm*, and instead thereof have divers large bladders made of thin transparent membranes, with pretty large holes out of one into the other. These membranes seem to me to serve for *ligaments*, or *braces* to the *viscera*, as well as to contain air. Towards the upper part each lobe of the lungs is perforated in two places with large apertures; whereof one is towards the outer, the other towards the inner part of the lobe. Through these perforations the air hath a passage into the belly, (as in *book i. chap. 1. note (b)*), that is, into the forementioned bladders; so that by blowing into the *aspera arteria*, the lungs will be a little raised, and the whole belly blown up so as to be very turgid. Which doubtless is a means to make their bodies more or less buoyant, according as they take in more or less air, to facilitate thereby their ascents and descents; like as it is in the *air-bladders* of fishes in the last cited place, *note (i) **.

* In birds there are a number of air-cells interspersed through the whole body, even in the bones. These cells are connected with the lungs, and may be filled or emptied at pleasure. They are of singular use for flight, by rendering their bodies lighter in proportion to their bulk; and they assist in prolonging their song. These cells are situated in the cellular membrane of the belly, and under their wings; and except in the order of anseres, and the genera of coots and snipes, they are chiefly distributed in the cavities of the bones, which are void of marrow; such as the bones of the thighs and wings, the breast-bone, ribs, rump-bones, shoulder-blades, collar-bone, back-bone, and even sometimes in the bones of the scull and the lower jaw. See *Kerr's Linnaeus. Anim. King. of Birds.*

through the air to bear the large and strong muscles which move the wings, and to counterpoise the body and support and rest it upon at roost. The *neck* also might deserve our notice, always either exactly proportioned to the length of the legs, or else longer to hunt out food, to search in the waters (*b*); as also to counterpoise the body in flight (*i*). And lastly, I might here take notice of the defect of the diaphragm, so necessary in other animals to respiration; and also of divers other parts redundant, defective, or varying from other animals. But it would be tedious to insist upon all, and therefore to the examples already given, I would rather recommend a nice inspection

(*b*) *Such birds as have long legs have also a long neck; for that otherwise they could not commodiously gather up their food either on land or in the water. But on the other side those which have long necks have not always long legs, as in swans, whose necks serve them to reach to the bottom of rivers, &c. Willughby's Ornithol. l. 1. c. 1. sect. 7.*

(*i*) We have sufficient instances of this in *geese, ducks, &c.* whose wings (their bodies being made for the convenience of swimming) are placed out of the centre of gravity nearer the head. But the extending the neck and head in flight causeth a due equipoise and libration of the body upon the wings; which is another excellent use of the long necks of these birds, besides that of reaching and searching in the waters for their food.

But in the *heron*, whose head and long neck (although tucked up in flight) over-balance the hinder part of the body; the long legs are extended in flight to counterpoise the body, as well as to supply what is wanting in the tail from the shortness of it.

tion (*k*) of those curious works of God, which would be manifest demonstrations of the admirable contrivance and œconomy of the bodies of those creatures.

From the fabric therefore of their bodies, I shall pass to a glance of one or two things relating to their *state*, and so conclude this genus of the animal world.

(*k*) *Steno* thus concludes his myology of the eagle, *Imperfecta hæc musculorum descriptio, non minùs arida est legentibus, quàm inspeclantibus fuerit jucunda eorundem præparatio. Elegantissima enim mechanices artificia, creberrimè in illis obvia, verbis non nisi obscure exprimuntur, carniùm ductu, tendinùm colore, insertionum proportione, & trochlearum distributione oculis exposita omnem superant admirationem.*—"This imperfect description of the muscles must be as dry to those who read it, as the examination of them by the eye must be pleasant to those who have seen their preparations. For those most elegant contrivances of mechanism, which very frequently occur in them, can be but obscurely expressed in description; but the tracing of the flesh, the colour of the tendons, the proportion of their several insertions, and the distribution of the trochlea, when seen by the eye, are most wonderful to behold."—*Steno in Blas. Anat. Animal. p. 2. c. 4.*

C H A P. III.

Of the Migration of Birds.

CONCERNING the *state* of this tribe of *animals*, the first thing I shall speak of (by reason God himself instanceth in it) shall be their migration, mentioned *Jer. viii. 7. Yea the stork in the heaven knoweth her appointed times, and the turtle, and the crane, and the swallow observe the time of their coming; but my people, &c.*

In which act of migration there are two things to me exceedingly notable. One is what the text speaks of, their knowing their proper times for their *passage* when to come (*a*), when to go; as also that some should come when others go; and some others go when these come. There is no doubt but the temperature of the air, as to heat and cold, and their natural propensity to breed their young, may be great incentives to those creatures to change their habitation. But yet it is a very odd instinct, that they should at all shift their habitation;

(*a*) *Curiosa res est, scire, quàm exactè hoc genus avium [gruum] quotannis observet tempora sui reditus ad nos. Anno 1667, primæ grues comparuerunt in campestribus Pisæ 20 Feb. &c.*—"It is admirable to consider with what exactness this kind of birds (cranes) observe the time of their annual return to our country. In the year 1667, the first cranes made their appearance in the fields about Pisa on the 20th of February."—*F. Redi Exp. Nat. p. 100. ubi plura.*

ation; that some certain place is not to be found in all the terraqueous globe affording them convenient food and habitation all the year, either in the colder climes, for such as delight in the colder regions, or the hotter for such *birds of passage* as fly to us in summer.

Also it is somewhat strange, that those untaught unthinking creatures should so exactly know the best and only proper seasons to go and come. This gives us good reason to interpret the מְעֵרָה appointed times (b) in the text, to be such times as the Creator hath appointed those animals, and hath accordingly, for this end, imprinted upon their natures such an instinct, as exciteth and moveth them thus, at proper times, to fly from a place that would obstruct their generation, or not afford convenient food for them and their young, and betake themselves to another place, affording all that is wanting for food or incubation.

And

(b) From יָעַר *indixit, constituit, scil. locum, vel tempus, ubi vel quando aliquid fieri debet.*—"Appointed, or ordained a time or a place, when and where any thing was to happen."—*Buxt. in verb.*

De voluntate suâ certiore reddidit.—"Certified us of his will."—*Con. Kircher concordant. Pars. 1. Col. 1846.* מְעֵרָה *Generaliter pro re aliquâ certâ, attestatâ, & definitâ accipitur. 1. Pro tempore certo & constituto. 2. Deinde pro festo seu solemnitate, quâ certo & statò tempore celebratur. 3. Pro loco certo constituto.*—"מְעֵרָה is generally used to signify any thing certain, well attested, and defined. 1. For a certain and appointed time. 2. For a feast or solemnity kept at a stated time. 3. For an appointed place."—*Id. Ibid. Col. 1847.*

And this leads me to another thing remarkable in this act of migration; and that is, that those unthinking creatures should know what way to steer their course (*c*), and whither to go. What but the great Creator's instinct should ever move a poor foolish bird to venture over vast tracts of land, but especially over large seas? If it should be said, that by their high ascents up into the air, they can see cross the seas; yet what should teach
or

(*c*) *Quis non cum admiratione videat ordinem & politiam peregrinantium avium, in itinere, turmatim volantium, per longos terrarum & maris tractus absque acu marinâ?—Quis eas certum iter in aëris mutabili regione docuit? Quis præterite signa, & futura viæ indicia? Quis eas ducit, nutrit, & vitæ necessaria ministrat? Quis insulas & hospitium illa, in quibus victum reperiunt, indicavit; modumque ejusmodi loca in peregrinationibus suis inveniendi? Hæc sanè superant hominum captum & industriam, qui non nisi longis experientiis, multis itinerariis, chartis geographicis,—& acûs magneticæ beneficio,—ejusmodi marium & terrarum tractus conficere tentant & audent.*—“For who can consider without admiration the wonderful order and polity of those birds that migrate to distant countries; and the regularity of their journey, travelling in flocks, without compass to direct them, through a great expanse of air and sea? Who has taught them their steady course through the changeable region of the air? Who discovers to them how far they have travelled, and how far they have yet to go? Who conducts them, feeds them, and supplies the necessaries of life? Who points out those islands and safe resting places in which they may find their food, or shews them a way of discovering such places? Surely these things far surpass the understanding and research of man, who cannot, but by long experience, many journals of travellers, and the aid of geographical charts, attempt to find his way through such tracts of land and sea.”—*Lud. de Beaufort. Cosmop. Divina sect. 5. c. 1.*

or persuade them, that that land is more proper for their purpose than this? That *Britain* (for instance) should afford them better accommodations than *Egypt* (*d*), than the *Canaries*, than *Spain*,

or

(*d*) I instance particularly in *Egypt*, because Mr. *Willughby* thinks *swallows* fly thither, and into *Æthiopia*, &c. and that they do not lurk in holes, or under water, as *Olaus Magnus* reports. Vide *Ornith.* lib. 2. cap. 3. But *Etmuller* puts the matter out of doubt, who saith, *Memini me plures, quàm quas medimnus caperit, hirundines artè coacervatas intra piscinæ cannas, sub glacie prorsus ad sensum exanimis pulsantes tamen, reperisse.*—

“ I remember to have seen as many swallows as would have filled a bushel lying heaped up together among the reeds of a fish-pond, under the ice, dead to all appearance, except that they had some small pulsation of the heart.”—*Etmuller. Dif. fert.* 2. cap. 10. sect. 5. This, as it is like what *Ol. Magnus* saith, so is a confirmation of it. The archbishop’s account is, *In septentrionalibus aquis sæpius casu piscatoris extrahuntur hirundines, in modum conglomeratæ massæ, quæ ore ad os, & alâ ad alam, & pede ad pedem post principium autumnî sese inter cannas descensurâ colligârunt.*—*Massa autem illa per imperitos adolescentes—extracta, atque in æstuarîa portata, caloris accessû hirundines resolutæ, volare quidem incipiunt, sed exiguo tempore durant.*—“ In the waters of the northern countries the fishermen often draw out swallows conglomerated into a mass. These birds, after the coming on of autumn, joining beak to beak, wing to wing, and foot to foot, thus go down among the reeds. The mass being taken out by boys, and carried into a warm place, the swallows begin to revive with the heat, and fly about, but live only a short time.” *Ol. Mag. Hist.* l. 19. c. 20.

Since my penning this note, we had, at a meeting of the Royal Society, Feb. 12, 171 $\frac{2}{3}$, a farther confirmation of *swallows* retiring under water in winter from Dr. *Colas*, a person very curious in those matters; who speaking of their way of fishing in the northern parts, by breaking holes and drawing their

or any of those many intermediate places over which some of them probably fly.

And lastly, to all this, let us briefly add the accommodations these *birds of passage* have to enable them to take such long flights, viz. the length of their wings, or their more than ordinary strength (*e*) for flight.

their nets under the ice, saith, that he saw sixteen swallows so drawn out of the lake of *Samrodt*, and about thirty out of the king's great pond in *Rosneilen*; and that at *Schlebitten*, near an house of the earl of *Dohna*, he saw two swallows just come out of the waters that could scarce stand, being very wet and weak, with their wings hanging on the ground. And that he hath observed the swallows to be often weak for some days after their appearance.

(*e*) As *swallows* are well accommodated for long flights by their long wings, so are *quails* by the strength of their *pectoral muscles*, by the breadth of their wings, &c. For quails have but short wings for the weight of their body; and yet they fly from us into warmer parts against winter, and to us in spring, crossing our seas. So divers travellers tell us they cross the *Mediterranean* twice a year, flying from *Europe* to *Africa* and back again. Thus *Bellonius*, in Mr. *Willughby* saith, *When we sailed from Rhodes to Alexandria of Egypt, many quails flying from the north towards the south were taken in our ship; whence I am verily persuaded that they shift places. For formerly also, when I sailed out of the isle of Zant to Morea, or Negropont, in the spring-time, I had observed quails flying the contrary way, from south to north, that they might abide there all summer. At which time also there were a great many taken in our ship.* Ornith. p. 170.

C H A P. IV.

Of the Incubation of Birds.

ANOTHER thing relating to the state of this tribe of animals, is their *incubation*.

And first, the egg itself deserves our notice. Its parts within, and its crusty coat without, are admirably well fitted for the business of incubation. That there should be one part provided for the formation of the body (*a*), before its *exit* into the world, and another for its nourishment, after it is come into the world, till the bird is able to shift for, and help itself; and that these parts should be so accurately braced, and kept in due place (*b*), is certainly

(*a*) *The chicken is formed out of, and nourished by the white alone, till it be grown great. The yolk serves for the chicken's nourishment, after it is well grown, and partly also after it is hatched. For a good part of the yolk remains after exclusion, being received into the chicken's belly; and being there reserved, as in a storehouse, is by the [appendicula, or ductus intestinalis], as by a funnel, conveyed into the guts, and serves instead of milk, &c. Willughby's Ornith. l. 1. c. 3. Ipsum animal ex albo liquore ovi incorporatur. Cibus ejus in lutco est.—“The animal itself is formed from the white of the egg. It receives its nourishment from the yolk.” Plin. lib. 10. cap. 53.*

Aristotle saith, the long sharp eggs bring females; the round ones, with a larger compass at the sharper end, males. Hist. An. l. 6. c. 2. After which, he tells of a sot at Syracuse, that sat drinking so long, till eggs were hatched; as also of the custom of Egypt, of hatching eggs in dunghills.

(*b*) *As the shell and skin keep the yolk and two whites together; so each of the parts, (the yolk and inner white at least,)*

certainly a designed, as well as curious piece of workmanship.

And then as to the act itself, of *incubation*, what a prodigious instinct is it in all, or almost all the several species of birds, that they, and only they, of all creatures, should betake themselves to this very way of generation? How should they be aware that their eggs contain their young, and that their production is in their power (*c*)? What should

move
least,) are separated by membranes, involving them. At each end of the egg is a treddle, so called, because it was formerly thought to be the sperm of the cock. *But the use of these*, (saith Dr. Harvey in *Willugh. Ornith. c. 3.*) *is to be, as it were, the poles of this microcosm, and the connections of all the membranes twisted and knit together, by which the liquors are not only conserved, each in its place, but do also retain their due position one to another.* This, although in a great measure true, yet doth not come up to what I have myself observed; for I find, that these *chalazæ*, or *treddles*, serve not barely to keep the liquors in their place, and position to one another; but also to keep one and the same part of the yolk uppermost, let the egg be turned nearly which way it will; which is done by this mechanism; the *chalazæ* are specifically lighter than the whites, in which they swim; and being braced to the membrane of the yolk, not exactly in the *axis* of the yolk, but somewhat out of it, cause one side of the yolk to be heavier than the other; so that the yolk being by the *chalazæ* made buoyant, and kept swimming in the midst of two whites, is by its own heavy side kept with the same side always uppermost; which uppermost side, I have some reason to think, is that on which the *cicatricula* lies; that being commonly uppermost in the shell, especially in some species of eggs more, I think, than others.

(*c*) All birds lay a certain number of eggs, or nearly that number, and then betake themselves to their incubation; but if their eggs be withdrawn, they will lay more. Of which, see Mr. Ray's *Wis. of God*, p. 137.

move them to betake themselves to their nests, and there with delight and patience to abide the due number of days? And when their young are gotten into the world, I have already shewn how admirable their art, their care, and *στοργή* is in bringing them up until, and only until, they are able to shift for themselves.

And lastly, when almost the whole tribe of birds do thus, by incubation, produce their young, it is a wonderful deviation, that some few families only, should do it in a more novercal way (*d*), without any care or trouble at all, only by laying their eggs
in

(*d*) The *tabon* is a bird no bigger than a chicken, but is said to lay an egg larger than a goose's egg, and bigger than the bird itself. These they lay a yard deep in the sand, where they are hatched by the warmth of the sun; after which they creep out, and get to sea for provisions. *Navarett's Account of China in Collect. of Voyages*, vol. i. This account is, in all probability, borrowed from *Nieremberg* or *Hernandez*, (that copied from him,) who call this bird by the name of *daie*, and its eggs *tapun*, not the bird itself, as *Navarette* doth. But my friend Mr. Ray saith of it, *Historia isthæc proculdubio fabulosa & falsa est. Quamvis enim aves nonnullæ maxima ova pariunt, ut v. g. alkæ, lomwiæ, anates arcticæ, &c. hujusmodi tamen unum duntaxat, non plura, ova ponunt antequam incubent: nec ullam in rerum naturâ avem dari existimo cujus ova albumine careant: cum albumen præcipua ovi pars sit, quodque primum fœtui alimentum subministrat.*—“The history of this bird is undoubtedly false and fabulous; for although some birds produce very large eggs, as for example, awks, *lomwia*, arctic ducks, &c. but these kind of birds lay only one egg before incubation: nor do I believe that there is any bird in nature whose eggs have no white: for the white is indeed a principal part of the egg, and furnishes the chick with its first nourishment.”—*Raii Synop. Av. Meth.* p. 155.

in the sand, exposed to the heat and incubation of the sun. Of this the Holy Scripture itself gives us an instance in the ostrich: of which we have an hint, *Lam. iv. 3. The daughter of my people is become cruel, like the ostriches in the wilderness.* This is more plainly expressed in *Job xxxix. 14, 15, 16, 17. [The ostrich] leaveth her eggs in the earth, and warmeth them in the dust, and forgetteth that the foot may crush them, or that the wild beast may break them. She is hardened against her young ones, as though they were not hers: her labour is in vain, without fear. Because God hath deprived her of wisdom, neither hath he imparted unto her understanding.* In which words I shall take notice of three things: 1. Of this anomalous way of generation. It is not very strange, that no other incubation but that of the sun, should produce their young; but it is very odd and wonderful that any one species should vary from all the rest of the tribe. But above all, 2. The singular care of the Creator, in this case, is very remarkable, in supplying some other way the want of the parent-animals care and *στοργή (e)*, so that the young should, notwithstanding,

(e) *The eggs of the ostrich being buried in the sand, are cherished only by the heat of the sun, till the young be excluded. For the writers of natural history do generally agree, that the old birds, after they have laid and covered their eggs in the sand, forsake them, and take no more care of them.—Willugh. Ornith. l. 2. c. 8. sect. 1.*

But there is another *ostrich [of America]* which *Acaret* tells us of, that takes more care of her young, by carrying four of her eggs, a little before she hatcheth, to four parts of her nest, there

withstanding, be bred up in those large and barren deserts of *Arabia* and *Africa*, and such like places where those birds dwell, the most unlikely and unfitting (in all human opinion) to afford sustenance to young helpless creatures; but the fittest therefore to give demonstrations of the wisdom, care, and especial providence of the infinite Creator and Conservator of the world. 3. The last thing I shall remark is, that the instincts of irrational animals, at least of this specified in the text, is attributed to God. For the reason the text gives why the *ostrich* is hardened against her young ones, as though they were not hers, is, because God hath deprived her of wisdom, and not imparted understanding to her; i. e. he hath denied her that wisdom, he hath not imparted that understanding, that *στοργή*, that natural instinct to provide for and nurse up her young, that most other creatures of the same and other tribes are endowed with.

Thus I have dispatched what I intended to insist upon concerning the state of this set of animals; of which, as also of their admirable instincts, a great deal more might deserve our especial observation; particularly the admirable curiosity, art, and variety of nidification (*f*) used among the various species of birds; the great sagacity, and many artifices used by them in the investigation and capture

there to breed worms for food for her young. *Acaret's Disc. in Philosoph. Transf.* No. 89.

(*f*) See book iv. chap. 13.

ture of their prey (*g*), the due proportion of the more and less useful, the scarcity of the voracious and pernicious, and the plenty of the mansuete and useful (*h*). Also the variety of their motion and flight might deserve consideration, the swiftness of such whose food is to be sought in far distant places, and different seasons (*i*); the slower motion, and short flights of others more domestic; and even the awkwardness of some others to flight, whose food is near at hand, and to be gotten without any great occasion of flight (*k*). These, and divers other such like things as these, I say, I might have spoken more largely unto; but I shall pass them by with only a bare mention, having already taken notice of them in the company of other matters of the like nature, and manifested them to be acts of excellent design, wisdom, and providence, in the great Creator.

(*g*) See *book iv. chap. 11*, and *14*.

(*h*) See *book iv. the beginning of chap. 10*.

(*i*) See *book iv. chap. 8*.

(*k*) The *colymbi*, or *douckers*, having their food near at hand in the waters, are remarkably made for diving therein. Their heads are small, bills sharp-pointed, wings small, legs flat and broad, and placed backward, and nearer the tail than in other birds; and lastly, their feet; some are whole footed, some cloven footed, but withal fin-toed. Vide *Willugh. Ornith. lib. 3. sect. 5*.

C H A P. V.

The Conclusion.

AND now, if we reflect upon the whole matter, we shall here find another large tribe of the creation, abundantly setting forth the wisdom and glory of their great Creator. We praise the ingenuity and invention of man for the contrivance of various pneumatic engines; we think them ingenious, even for their unsuccessful attempts to swim in and sail through that subtle element the air; and the curious mechanism of that Artist is had in remembrance, and praised to this day, who made a dove, or an *eagle* (a) to fly but a short space. And is not therefore all imaginable honour and praise due to that infinite Artist, who hath so admirably contrived and made all the noble variety of birds; who hath with such incomparable curiosity and art formed their bodies from head to tail, without and within, that not so much as any muscle or bone, no, not even a feather (b) is unartificially made,

(a) Vide book v. chap. i. note (aa).

(b) *Deus non solum angelum & hominem, sed nec exigui & contemptibilis animantis viscera, nec avis pennulam, nec herbae flosculum, nec arboris folium, sine suarum partium convenientiâ dereliquit.—*

“ For God has not only formed angels and men, but even the

made, misplaced, redundant, or defective, in all the several families of this large tribe? But every thing is so incomparably performed, so nicely fitted up for flight, as to surpass even the imitation of the most ingenious artificer among mortal rational beings.

minuteſt entrails of the moſt contemptible inſect, with a view to the moſt perfect and convenient arrangement of its parts.”—*Auguſtin de Civ. Dei*, l. 5. c. 11.

B O O K VIII.

Of Insects and Reptiles.

C H A P. I.

Of Insects in General.

HAVING dispatched that part of the animal world which used to be accounted the more perfect, those animals styled less perfect or imperfect will next deserve a place in our *survey*, because, when strictly inquired into, we shall find them to be so far from deserving to be accounted mean and despicable parts of the creation, owing their original and production to putrefactions, &c. as some have thought, that we shall find them, I say, noble and most admirable works of God. For, as the famous natural historian *Pliny* (a) prefaceth his *Treatise of Insects*, to prevent the reproach of condescending (as might be thought) to so mean a subject: *In great bodies*, saith he, *Nature had a large and easy shop to work upon obsequious matter; where-*
as,

(a) *In magnis siquidem corporibus*, &c.—“As in great bodies,” &c.—*Plin. Nat. Hist.* l. 11. c. 2.

as, in these so small, and as it were no bodies, what footsteps of reason, what power, what great perfection is there? Of this having given an instance or two of the exquisite senses, and curious make of some insects (b), he then goes on, *We admire, faith he, the turrigerous shoulders of elephants, the lofty necks and crests of others; but, faith he, the nature* of

(b) *Ubi tot sensus collocavit in culice? et sunt alia dictu minora. Sed ubi visum in eo prætendit? ubi gustatum applicavit? ubi odoratum inseruit? Ubi verò truculentam illam & portione maximam vocem ingeneravit? Quâ subtilitate pennas adnexuit? prælongavit pedum crura? disposuit jejunam caveam, uti alvum? avidam sanguinis, & potissimum humani, sitim, accendit? Telum verò perfodiendo tergori, quo spiculavit ingenio; atque ut in capaci, cum cerni non possit exilitas, ita recíprocâ geminavit arte, ut fodiendo acuminatum pariter sorbendoque fistulosum esset? Quos teredini ad perforanda robora cum sono teste dentes affixit; potissimumque è ligno cibatum fecit? Sed turrigeros elephantorum miramur humeros, taurorumque colla, & truces in sublime jactus, tigrum rapinas, leonum jubas, cum rerum Natura nusquam magis quam in minimis, tota sit.—“ Where has Nature fixed the senses of a gnat? Where is the seat of its sight, of its taste, of its smell? Where has she fixed the organs of that terrible and most sonorous voice? With what artifice hath she set on its wings, extended its legs, and formed its stomach and belly; given it a keen thirst for blood, especially for human blood? With what ingenuity has she furnished it with a weapon to perforate the skin; and working in a compass hardly visible, equally well as on the largest scale, has made that weapon at once sharp for piercing, and hollow for sucking up? What teeth has she given to the wood-louse for perforating the hardest oak, as is evidenced by the sound it makes; and has given it its chief sustenance from wood? We admire the turret-bearing shoulders of the elephant, the neck of the bull, and its power of tossing aloft with fury its enemy, the ravages of the tiger, and the mane of the lion; whereas the power of Nature is never so conspicuously seen as in the smallest things.”—*Plin. Nat. Hist.* l. 11. c. 2.*

of things is never more complete than in the least things. For which reason he entreats his readers, (as I do mine,) that because they slighted many of the things themselves which he took notice of, they would not therefore disdainfully condemn his accounts of them, since, saith he, in the contemplation of nature, nothing ought to seem superfluous.

Thus that eminent naturalist hath made his own and my excuse too; the force and verity whereof will farther appear, by what I shall say of these animals which (as despicable as they have been, or perhaps may be thought) we shall find as exquisitely contrived, and curiously made for that place and station they bear in the world, as any other part of the animal world. For if we consider the innumerable variety of their species, the prodigious number of individuals *, the shape and make of their little bodies, and every part thereof, their motion, their instincts, their regular generation and production; and,

* Mr. Reaumur found that a single queen-bee had laid in the months of March and April 12,000 eggs, so that the swarm, which left the hive in May, consisted of near 12,000 bees, all produced from one mother; but these calculations fall short of those made by Mr. Lewenhoeck of the produce of a fly, whose larva feeds on flesh, putrid carcases, &c. which multiply prodigiously, and in a very short space of time. One of these flies laid 144 eggs, from which in one month were produced as many flies; so that supposing one half of these to be females, each equally fruitful as its mother, there would be in the third month 746,496 all produced in three months from one fly.—*Adams's Microscopical Essays.* EDITOR.

and, to name no more, the incomparable beauty and lustre of the colours of many of them, what more admirable and more manifest demonstration of the infinite Creator, than even this little contemned branch of the animal world? But let us take a short view of particulars.

CHAP. II.

Of the Shape and Structure of Insects.

LET us begin with the shape and fabric of their bodies *. Which although it be somewhat different from that of birds, being particularly, for the most part, not so sharp before, to cut and make way through the air, yet is better adapted to their manner of life. For considering that there is little necessity of long flights, and that the strength and activity of their wings doth much surpass the resistance their bodies meet with from the air, there was no great occasion their bodies should be so sharpened before.

* The following particulars are characteristic of the insect tribe.

1. The body of insects is divided by *incisuræ* or transversal divisions; from which circumstance they have been termed *insects*, *insecta*, *εντομια*. 2. They are furnished with antennæ, which are placed upon the forepart of the head; these are jointed and moveable in various directions. 3. No insect in its perfect state, or after it has gone through all its transformations, has less than six legs, though many have more. There are some moths whose two fore-feet are so small as scarcely to deserve that name. 4. Insects are generally believed to have neither the organs of smell nor of hearing; at least they have not as yet been discovered; though it is said that Fabricius has lately found and described the organs of hearing in the lobster. 5. Insects do not respire by the mouth, but inspire and exhale the air by means of organs which are placed in the body. 6. They do not move the jaws up and down, but from right to left.

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before. But the condition of their food, and the manner of gathering it, together with the great necessity of accurate vision, by that admirable provision made for them by the reticulated *cornea* of their eyes; these things, I say, as they required a larger room, so were a good occasion for the largeness of the head, and its amplitude before. But for the rest of their body, all is well made, and nicely poised for their flight, and every other of their occasions.

And as their *shape*, so the *fabric* and *make* of their bodies is no less accurate, admirable, and singular; not built throughout with bones, and covered with flesh and skin, as in most other animals; but covered with a curious mail of a middle nature (*a*), serving both as skin and bone too, for the shape, as well as strength and guard, of the body; and as it were on purpose to shew, that the great Contriver of Nature is not bound up to one way only.

(*a*) *Insecta non videntur nervos habere, nec ossa, nec spinas, nec cartilaginem, nec pinguia, nec carnes, nec crustam quidem fragilem, ut quædam marina, nec quæ jure dicatur cutis: sed mediæ cujusdam inter omnia hæc naturæ corpus, &c.*—"Insects do not appear to have either nerves or bones, spine or cartilage, fat or flesh: neither do they seem to have a little crust or shell like some marine animals; nor can they be properly said to have a skin; but their bodies seem to be formed of something intermediate between all of these *.—*Plin. Nat. Hist. l. ii. c. 4.*

* That Pliny is mistaken when he asserts the want of nerves in insects, is evident from M. Lyonet's anatomy of the common caterpillar. See *postea*, p. 297. *note*.

CHAP. III.

Of the Eyes and Antennæ of Insects.

TO this last-mentioned guard, we may add, that farther guard provided in the *eyes* and *antennæ*. The structure of the eye is, in all creatures, an admirable piece of mechanism; but that observable in the eyes of insects so peculiar, that it must needs excite our admiration: fenced with its own hardness, yea, even its own accurate vision, is a good guard against external injuries; and its *cornea*, or outward coat, all over beset with curious, transparent, lenticular (*a*) inlets, enabling those creatures to

(*a*) The *cornea* of flies, wasps, &c. are so common an entertainment with the microscope, that every body knows it is a curious piece of lattice-work. In which this is remarkable, that every *foramen* is of a lenticular nature; so that we see objects through them topsy-turvy, as through so many convex glasses: yea, they become a small telescope, when there is a due focal distance between them and the *lens* of the microscope.

This lenticular power of the *cornea* supplies (as I imagine) the place of the crystalline, if not of the vitreous humour too, there being neither of those humours that I could ever find (although for truth sake, I confess I have not been so diligent as I might in this inquiry); but instead of *humours* and *tunics*, I imagine that every *lens* of the *cornea* hath a distinct branch of the *optic nerve* ministering to it, and rendering it as so many distinct eyes. So that as most animals are binocular, spiders for
the

to see (no doubt) very accurately every way, without any interval of time or trouble to move the eye towards objects.

And

the most part octonocular, and some (as Mr. *Willughby* thought, *Raii Hist. Insect.* p. 12.) senocular; so flies, &c. are multocular, having as many eyes as there are perforations in their *cornea*. By which means, as other creatures are obliged to turn their eyes to objects, these have some or other of their eyes ready placed towards objects, nearly all around them: thus particularly it is in the *dragon-fly*, (*libella*,) the greatest part of whose head is possessed by its eyes: which is of excellent use to that predacious insect, for the ready seeing and darting at small flies all around it, on which it preys *. See plate G, fig. 3.

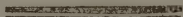
* Mr. York computed 14,000 hemispheres in the two eyes of a drone: Mr. *Lewenhoeck* reckoned 6236 in a silk-worm's two eyes in its fly-state; 3181 in each eye of a beetle, and 8000 in the two eyes of a common fly. The pearl eyes of the dragon-fly appear with a common reading-glass like shagreen; and Mr. *Lewenhoeck* reckoned in each eye of this insect, 12,544 lenses, placed in an hexagonal position; (see plate G, fig. 3.) each lens having six others round it. He also observed in the centre of each lens a minute transparent spot, brighter than the rest, supposed to be the pupil, surrounded with three circles, and in appearance seven times less than the diameter of the whole lens. The Abbé Catalan and others have since shewn, that all the eminences discoverable in the cornea of insects, have the necessary parts, and perform the offices of an eye. *Lewenhoeck* discovered the bundles of optic nerves, which serve these small lenses; and *Reaumur* supposes that these supply the place of all that is wanted behind the lenses for the organization of an eye complete for vision. See *Adams's Microscopical Essays*, and the Works of *Swammerdam*, for many other curious particulars relative to the eyes of insects.

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And as for the other-part, the *antennæ* or *feelers*, whatever their use may be in cleaning the eyes, or other such like use, they are, in all probability, a good guard to the eyes and head, in their walk and flight, enabling them, by the sense of feeling, to discover such annoyances, which by their proximity may perhaps escape the reach of the eyes and sight (*b*). Besides which, they are a curious piece
of

(*b*) It is manifest, that insects clean their eyes with their fore-legs, as well as *antennæ*. And considering, that as they walk along, they are perpetually feeling, and searching before them, with their *feelers* or *antennæ*; therefore I am apt to think, that besides wiping and cleaning the eyes, the uses here named may be admitted. For as their eyes are immovable, so that no time is required for the turning their eyes to objects; so there is no necessity of the *retina* or *optic nerve* being brought nigher unto or set farther off from the *cornea*, (which would require time,) as it is in other animals: but their *cornea* and *optic nerve*, being always at one and the same distance, are fitted only to see distant objects, but not such as are very nigh: which inconvenience the *feelers* obviate, lest it should be prejudicial, in occasioning the insect to run its head against any thing.

And that this, rather than the wiping the eyes, is the chief use of the *feelers*, is farther manifest from the *antennæ* of the *flesh-fly*, and many other insects, which are short and stait, and incapable of being bent unto or extended over the eyes. As also from others enormously long, such as those of the *capricornii*, or *goat-chafers*, the *caddew-fly*, and divers others, both beetles and flies*.



* The *antennæ* (improperly termed *feelers*) seem to be the distinguishing mark of the insect tribe. They are jointed and moveable in every part in which they differ from the horns of other animals; they are organs conveying some kind of sense, but what that is we cannot

of workmanship, and in many, a very beautiful piece of (c) garniture to the body.

(c) The lamellated *antennæ* of some, the clavellated of others, the neatly articulated of others, the feathered and divers other forms of others, of the *scarab*, *papilionaceous gnat*, and other kinds, are surprisngly beautiful when viewed through a microscope. And in some those *antennæ* distinguished the sexes; as in the *gnat-kind*, all those with tufts, feathers, and brush-horns are males; those with short single-shafted *antennæ* are females. See Plate G, figures a, b, c, d, e, f, g.

cannot with certainty say. Mr. Barbut supposes them to constitute or to contain the organs of hearing. They are tubular and filled with air, and some kind of humour, as appears from the *antennæ* of butterflies immersed in water. They are not probably organs of feeling, for the fore-feet or *palpi* of insects seem to be always employed in that purpose; and insects are observed to avoid carefully the touching of any hard substance with their *antenna*.

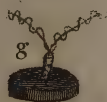
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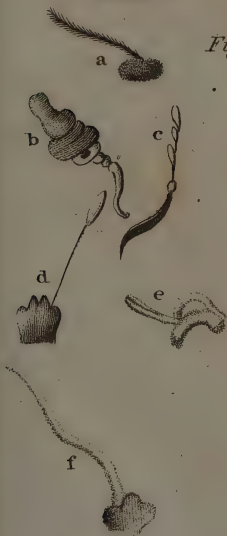
Fig. 3



Fig. 1



8



a.b.c.d.e.f.g. Antennae of different tribes, of Insects.

1. The Common house Fly magnified.

2. The Foot of the common house Fly magnified.

3. Part of the Cornea of the Libella or Dragon Fly magnified.

CHAP. IV.

Of the Parts and Motion of Insects.

FROM the head pass we to the members concerned in their motion. And here we have a copious subject if I was minded to expatiate. I might take notice of the admirable mechanism in those that creep; the curious oars in those amphibious insects that swim and walk (*a*); the incomparable provision made in the feet of such as walk, or hang upon smooth surfaces (*b*); the great strength

(*a*) All the families of *hydrocanthari*, *notonecti*, &c. have their hindmost legs made very nicely, with commodious joints flat, and bristles on each side towards the end, serving for oars to swim; and then, nearer the body, are two stiff spikes to enable them to walk when occasion is.

(*b*) I might here name divers flies, and other insects, who, besides their sharp-hooked nails, have also skinny palms to their feet to enable them to stick on glass, and other smooth bodies, by means of the pressure of the atmosphere. But because the example will illustrate another work of Nature, as well as this, I shall chuse a singular piece of mechanism in one of the largest sorts of *hydrocanthari*. Of these large ones there are two sorts, one largest all black, with *antennæ* handsomely embossed at the ends. The other somewhat lesser, hardly so black, with capillary *antennæ*; the forehead, edges of the *vaginæ*, and two rings on the *thorax*, of a tawny colour. The female hath *vagina* prettily furrowed; the male smooth. But that which is most to our purpose in this male is a flap, or hollowish cap near the

strength and spring in the legs of such as leap (*c*); the strong and well-made feet and talons of such as dig (*d*). And to name no more, the admirable faculty of such as cannot fly, to convey themselves with speed and safety by the help of their webs (*e*),
or

middle joint of the fore legs, which, when clapped on the shoulders of the female *in coitu*, sticks firmly thereon; after the manner as I have seen boys carry heavy stones, with only a wet piece of leather clapped on the top of the stone.

(*c*) Thus *grasshoppers* and *crickets* have brawny strong thighs, with long slender but strong legs, which enable them to leap with great agility and strength.

(*d*) I have wondered to see with what great quickness, art, and strength many *vespa-ichneumons*, *wild-bees*, and *beetles* perforate the earth, yea, even wood itself. But the most remarkable animal in this way is the *mole-cricket*, in *book iv. chap. 13. note (r)*. See Plate I, fig. 8.

(*e*) I have with pleasure often seen spiders dart out their webs, and sail away by the help thereof. For the manner of which see Mr. *Lowth. Abridg.* vol. ii. p. 794, from Dr. *Lister* and Dr. *Hulse*, who both claimed the discovery thereof; and do both seem to have hit thereupon, without any fore-knowledge of what each other hath discovered; as is said in the last cited place, and as I more particularly find by Mr. *Ray's Philos. Letters*, printed *ann. 1718*, p. 95, &c. By which also I find the two ingenious doctors were very modest in their claims, and very amicable in the matter. In one of Dr. *Lister's* to Mr. *Ray*, he thinks there is a fair hint of the darting of spiders in *Aristot. Hist. An.* l. 9. c. 39. and in *Pliny*, l. 11. c. 24. But for their sailing, that the ancients are silent of, and he thinks it was seen first by him. And in another letter, *Jan. 20, 1670*, speaking of the height spiders are able to fly, he saith, *The last October, &c. I took notice that the air was very full of webs, I forthwith mounted to the top of the highest steeple on the minster, [in York,] and could thence discern them yet exceeding high*

or some other artifice to make their bodies lighter than the air (*f*). These, and a multitude of other

high above me. Some that fell, and were entangled upon the pinnacles, I took, and found them to be lupi; which kind seldom or never enter houses, and cannot be supposed to have taken their flight from the steeple.

(*f*) There are (I imagine) divers animals as well as spiders that have some way of conveyance as little known to us as that of spiders formerly was. Thus the *squillulæ*, *pulices arborescentes*, and *microscopical animalcules* of the stagnating waters, so numerous in them, as to discolour sometimes the water, and make them look as if they were tinged red, yellow, or green, or covered with a thick green scum, all which is nothing but animalcules of that colour. That these creatures have some way of conveyance I conclude, because most stagnating waters are stocked with them, new pits and ponds, yea, holes and gutters on the tops of houses and steeples. That they are not bred there by equivocal generation every ingenious considering philosopher will grant; that they have not legs for travelling so far is manifest from inspection. And therefore I am apt to think, that they have some faculty of inflating their bodies, or darting out webs, and making their bodies buoyant, and lighter than air; or their bodies, when dry, may be lighter than air, and so they can swim from place to place; or the eggs of such as are oviparous may be light enough to float in the air. But when the viviparous (as my late ingenious friend Mr. *Charles King* shewed me the *pulices aquat. arboresc.* are); these (I say) cannot be this way accounted for. The cause of these latter suspicions was, that in the summer months I have seen the *pulices arboresc.* and the green scum on the waters (nothing but animalcules, as I said) lie in a manner dry on the surface of the waters; at which time (as I have shewn in *book iv. chap. 11. note (n),*) those animalcules copulate; and perhaps they may at the same time change their quarters, and seek out new habitations for their numerous offspring, as well as themselves.

other such like things as these, I might, I say, take notice of, as great evidences of the infinite Creator's wisdom. But lest I should be too tedious, I will confine my observations to the legs and wings only: and these, at first view, we find to be incomparably fitted up for their intended service, not to overload the body, nor in the least to retard it, but to give it the most proper and convenient motion. What, for example, can be better contrived and made for this service than the wings? Distended and strengthened by the finest bones, and these covered with the finest and lightest membranes, some of them adorned with neat and beautiful feathers (g), and many of them provided with the finest articulations, and foldings, for the wings to be withdrawn and neatly laid up in their *vaginae* and cases, and again readily extended for flight (h).

And

(g) It is well known to all persons any way conversant in microscopical observations, that these elegant colours of *moths* and *butterflies* are owing to neat and well-made feathers set with great curiosity and exactness in rows and good order.

(h) All that have *elytra*, *scarabs*, (who have whole *elytra*, or reaching to the *podex* or the *ῥμικολεὸς πτερόν*, such as *earwigs*, and *staphilini* of all sorts,) do, by a very curious mechanism, extend and withdraw their membranaceous wings (wherewith they chiefly fly); and it is very pretty to see them prepare themselves for flight, by thrusting out and unfolding their wings; and again withdraw those joints, and neatly fold in the membranes, to be laid up safely in their *elytra* or cases; for which service the bones are well placed, and the joints minif-

tring

And then for the poising of the body, and keeping it upright, and steady in flight, it is an admirable artifice and provision for this purpose; in some by four wings (*i*); and in such as have but two,

tring thereunto are accurately contrived for the most compendious and commodious folding up the wings*.

(*i*) For the keeping the body steady and upright in flight, it generally holds true, (if I mistake not,) that all bipennated insects have *poises* joined to the body under the hinder part of their wings; but such as have four wings, or wings with *elytra*, none. If one of the poises, or one of the lesser auxiliary wings be cut off, the insect will fly as if one side overbalanced the other until it falleth on the ground; so if both be cut off they will fly aukwardly and unsteadily, manifesting the defect of some very necessary part. These *poises*, or *pointels*, are, for the most part, little balls, set at the top of a slender stalk, which they can move every way at pleasure. In some they stand alone, in others (as in the whole *flesh-fly* tribe) they have little covers or shields under which they lie and move. The use,

* The wings of the earwig are so artificially folded up, and lie inclosed in their cases in so small a compass, that this insect is generally believed to have none. It very rarely indeed makes use of them. The cases under which they are concealed are not more than a sixth part of the size of each wing, though a small part of the wing may be discovered, on a careful inspection, projecting from under them. The upper part of the wing is crustaceous and opaque; but the under part is beautifully transparent. In putting up their wings they first fold back the parts A, B, (see Plate H, figure 2,) and then shut up the ribs like a fan, the strong muscles used for this purpose being seen at the upper part of the figure. EDITOR,

two, by pointels and poises placed under the wings on each side the body.

And lastly, it is an amazing thing to reflect upon the surprising minuteness, art, and curiosity of the joints (*k*), the muscles, the tendons, the nerves necessary to perform all the motions of the legs, the wings, and every other part. I have already mentioned this in the larger animals; but to consider that all these things concur in minute animals, even in the smallest mite, yea, the animalcules, that (without good microscopes) escape our sight; to consider, I say, that those minute animals have all the joints, bones, muscles, tendons, and nerves necessary to that brisk and swift motion that many of them have, is so stupendous a piece of curious art (*l*), as plainly manifesteth the power
and

use, no doubt, of these *poises* and *secondary* lesser wings is to poise the body, and to obviate all the vacillations thereof in flight, serving to the insect, as the long pole, laden at the ends with lead, doth the *rope dancer*.

(*k*) As all the parts of animals are moved by the help of these, so there is no doubt but the minute animals have such like parts. But the muscles and tendons of some of the larger insects, and some of the lesser too, may be seen with a microscope.

(*l*) The minute curiosities, and inimitable fineries, observable in those lesser animals, in which our best microscopes discover no botch, no rude ill made work, (contrary to what is in all artificial works of man,) do they not far more deserve our admiration than those celebrated pieces of human art? Such as the cup made of a pepper-corn, by *Oswald Nerlinger*, that held 1200 ivory cups, all gilt on the edges, and having each of them a foot, and yet affording room for 400 more, in the
Ephem.

and wisdom of the infinite Deviser of those imitable artifices. But having named those minute animals, why should I mention only any one part of their bodies, when we have, in that little compass, a whole and complete body, as exquisitely formed, and (as far as our scrutiny can possibly reach) as neatly adorned as the largest animal*?

Let

Ephem. Germ. T. 1. Addend. ad Obs. 13. Such also was Phaëton in a ring, which Galen thus reflects upon when he speaks of the art and wisdom of the maker of animals, particularly such as are small, *Quanto, faith he, ipsum minus fuerit, tanto majorem admirationem tibi excitabit; quod declarant opifices cum in corporibus parvis aliquid insculpant: cujus generis est quoddam nuper quidam in annulo Phaëtona quatuor equis invecum sculpsit. Omnes enim equi frænum, os, & dentes anteriores habebant, &c.*—"For the smaller the body the greater admiration will its structure excite; just as the elaborate work of an artist upon the minutest substance; as for example that of the sculptor, who cut for a ring the figure of Phaeton drawn by four horses; in which one might observe the bridle, the mouth, and the fore-teeth of each of the horses." And then having taken notice, that the legs were no bigger than those of a gnat, he shews that their make did not come up to those of the gnat; as also, faith he, *Major adhuc alia quædam esse videtur artis ejus, qui pulicem condidit, vis atque sapientia, quod, &c. Cum igitur ars tanta in tam abjectis animalibus appareat,—quantam ejus vim ac sapientiam in præstantioribus inesse putabimus?*—"How much greater must have been the power and wisdom of HIM who formed a flea?—And if such attributes are so clearly perceptible in the formation of the vilest and most insignificant insects, how much more are they apparent in the structure of the nobler animals?"—*Galen. de Us. Part. l. 17. c. 1. fin.*

* The organ of sound in the grasshopper is an instrument at once so complicated and so curiously adapted to its purpose,

Let us consider, that there we have eyes, a brain, a mouth, a stomach, entrails, and every other part of an animal body, as well as legs and feet; and that

as to render it one of the most convincing proofs of that admirable design, which is equally conspicuous in the structure of the most minute as well as of the largest animals. "The grasshopper," says Mr. Bonnet, "is a kind of ventriloquous creature; the organ of his voice is situated in the belly. The male only sings; the female is mute, and it is probable the music of the male is not displeasing to her. On the belly of the male are two scaly plates nearly circular, which being lifted up we are immediately struck with the apparatus they unfold, and cannot but acknowledge that there is a determinate end in the formation of them, analogous to that we so clearly discover in a *larynx* or *glottis*. We at first perceive a great cavity divided into two lodges by a triangular piece, at the bottom of which is a kind of transparent mirror through which one may discern the interior parts of the animal. Besides these lodges there are two little intrenchments in the great cavity, which are lined with a very elastic membrane regularly furrowed and destined to perform the functions of the tympanum. If a feather be drawn over the skin of these tympana, the grasshopper will be made to sing; and the same will happen in a grasshopper that has been long dead, as well as in a living one. The furrows, or regular folds of the elastic membrane, are so many little sonorous instruments which have each their peculiar sound. The air being agitated or modified by these instruments, afterwards resounds in the lodges, where it is likewise modified by the different parts contained in them in like manner as it is modified by the cavities of the mouth and nose. Two great muscles, formed by the union of a prodigious number of straight fibres are destined to put in motion the sonorous furrows, which is the immediate cause of that sound so harsh to our ears."—*Bonnet, Contemplation de la Nature*, part 10. ch. 28. EDITOR.

that all those parts have each of them their necessary *apparatus* of nerves, of various muscles, and every other part that other insects have*; and that all is covered and guarded with a well-made tegument, beset with bristles, adorned with neat imbrications, and many other devices. And lastly, let us consider in how little compass all art and curiosity may lie, even in a body many times less than a small grain of sand (*m*), so that the least drop of water can contain many of them, and afford

(*n*) It will, in some measure, appear how wonderfully minute some microscopical animalcules are by what follows in the next note (*n*): But because more particular examples would be endless, I shall refer to the observations of Mr. *Leuwenhoeck* and others in the *Philos. Transf.* and elsewhere.

* Mr. Lyonet, who has written a treatise on one single insect, the *coffus caterpillar which lives on the leaves of the willow*, a work celebrated by Mr. Bonnet in the highest terms of panegyric, has shewn from the anatomy of that minute animal, that its structure and organization is almost as complicated as that of the human body. He has found it necessary to employ twenty figures to explain the organization of the head, which contains 228 different muscles. There are 1647 muscles in the body, and 2066 in the intestinal tube, making in all 40,141 muscles. There are 94 principal nerves which divide into innumerable ramifications. At figure 1, Plate H, may be seen a delineation of the nerves of the head, as observed from the under part; but excepting in two or three nerves, which may be easily distinguished, one only of each pair is drawn, to avoid confusion. The tracheal artery of this caterpillar, as traced by Mr. Lyonet, divides itself into 1326 different branches.

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ford them also sufficient room to dance and frisk about in (*n*).

Having surveyed as many of the parts of insects as I care to take notice of, I shall in the next place say somewhat of their state and circumstances of life. And here I shall take notice only of two things, which have been only hinted at before, but will deserve more particular consideration here as being acts of a wonderful instinct, namely, their security of themselves against winter, and their special care of preserving their species.

(*n*) It is almost impossible, by reason of their perpetual motion, and changing places, to count the number of the animalcules in only a drop of the green scum upon water; but I guess I have sometimes seen not fewer than 100 frisking about in a drop no bigger than a pin's head. But in such a drop of pepper-water a far greater number, these being much less than those.

Fig. I.

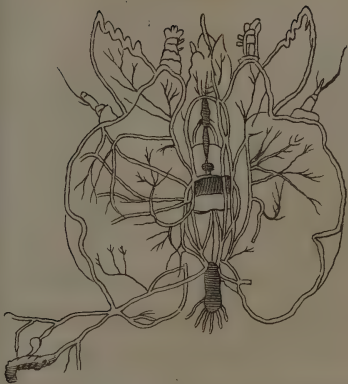


Fig. 3.



Fig. 4.

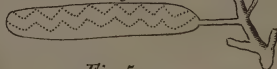


Fig. 5.

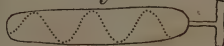


Fig. 2.

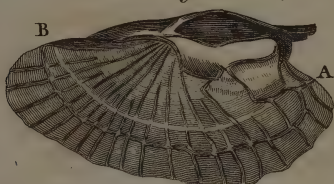


Fig. 6.



Fig. 8.



Fig. 7.



Fig. 9.



Fig. 10.



Fig. 11.



Fig. 12.



Fig. I. Exhibits the nerves of the head of the Cossus Caterpillar that feeds on the leaves of the Willow, as dissected by M^r Lyonet: excepting in two or three, one only of each pair is delineated.

Fig. 2. Shews the wing of an earwig magnified about four times.

Fig. 3. 4. 5. Disposition of the eggs in the spawn of Gnats.

Fig. 6. 7. 8. The Gnat in its vermicular state.

Fig. 9. 10. 11. The Mechanism of the Vanes of the feathers of birds.

Fig. 12. Part of the inner ear of birds.

CHAP. V.

The Sagacity of Insects to secure themselves against Winter.

IT is an extraordinary act of instinct and sagacity, observable in the generality of the insect-tribe, that they all take care to secure themselves, and provide against the necessities of winter. That when the distresses of cold and wet force them they should retire to warm and dry places of safety, is not strange; but it is a prodigious act of the infinite Conservator's care to enable some to live in a different kind of insect-state; others to live, as without action, so without food; and others that act and eat to lay up in summer sufficient provisions against the approaching winter. Some, I say, live in a different state, for having sufficiently fed, nourished, and bred up themselves to the perfection of their *vermicular, nympha-state*, in the summer months, they then retire to places of safety, and there throw off their *nympha*, and put on their *aurelia* or *chrysalis-state* for all the winter, in which there are no occasions for food *. This
is

* A theory of the metamorphoses of insects has been suggested by Mr. Bonnet. "An insect," says he, "that must moult five times before it is invested with the form of a chrysalis,

is the constant method of many families of the insect-tribe (a).

But

(a) It would be endless to enter into particulars here, because all the *papilionaceous*, *flesh*, and *ichneumon-fly* tribes, and all others that undergo the *nymph* and *aurelia* state between that of the egg and *mature* state, (which are very numerous,) appertain to this *note*. For a sample therefore only I shall take what some may think a mean one, but if considered deserves our admiration, and that is the sagacity of the *white butterfly caterpillar*, which having fed itself its due time then retires to places of security. I have seen great trains of them creeping up the walls and posts of the next houses, where, with the help of some cobweb-like filaments, they hang themselves to the ceilings, and other commodious places, and then become *aurelia*; in which state and places they hang secure from wet and cold till the spring and warmer months, when they are transmuted into butter-flies. See Plate I. fig. 1, 2, 3, 4, 5.

chrysalis, is a compound of five organised bodies inclosed within each other, and nourished by common viscera placed in the centre. As the bud of a tree is to the invisible buds it incloses, so is the exterior part of a caterpillar, newly hatched, to the interior bodies it conceals in its bosom. Four of these bodies have the same essential structure, and this structure is that which is peculiar to the insect in the state of a caterpillar. The fifth body, which is very different, is that of the chrysalis. The respective state of their bodies is in proportion to their distance from the centre of the animal. Those that are farthest off have more consistence, and unfold themselves soonest. When the exterior body has attained its full growth, the interior, which immediately follows, is by that time considerably unfolded. It soon finds itself lodged in two narrow a compass. It stretches on all sides the sheaths that encompass it. The vessels which convey the nourishment to these coverings being broken

But there are others, and some of them in their most perfect state too, that are able to subsist in a kind

broken or stifled by this violent distension cease to act. The skin wrinkles and dries up. At length it opens, and the insect appears clothed with a new skin and new organs. A fast of a day or two precedes each moulting. It is probably occasioned by the violent state in which all the organs then are. Perhaps it might be also necessary in order to promote the success of the operations, and prevent obstructions, settlings, &c. Be this as it may, the insect is always very weak after every moulting. All its organs are yet affected by the state they were in under the covering they are just disengaged from. The scaly parts, as the head and legs, are almost entirely membranous, and are all imbued with a liquor that insinuates itself betwixt the two skins, and facilitates their separation. But this moisture evaporates by degrees; all the parts acquire a consistence, and the insect is in a condition to act. When we have once conceived that all the exterior parts of the same kind are jointed into each other, or laid one on another, the production of new organs has nothing embarrassing in it; and with regard to this there should not be any essential difference betwixt the five moultings we have supposed to precede the transformation. Nothing more is requisite in all that, but a simple *developement*. But it is not the same with respect to the changes that happen in the viscera before, during, and after the metamorphosis. Here we are constrained to conjecture in the dark. It does not appear that the insect changes its viscera as it does its skin. Those which existed in the caterpillar exist likewise in the chrysalis; but they are modified, and it is the nature of these modifications, and the manner by which they are performed, that we are desirous of penetrating, but which elude our researches. A little before the metamorphosis the caterpillar voids the membrane that lines the inside of the intestinal bag. This bowel, which has hitherto di-

kind of torpitude, or sleeping-state, without any food at all; by reason as there is no action, so no waste of body, no expence of spirits, and therefore no need of food (*b*).

But

(*b*) I shall not name any of the particular species of insects which live in this state, because they are very numerous, but only remark two things observable in their sagacity in this matter: 1. That they are not driven by stress of weather to their retirement, but seem as naturally to betake themselves thereto, as other animals do to rest and sleep. For before the approach of cold weather, towards the end of summer, we may see some kinds of them flocking together in great numbers, within doors, (as *swallows* do a little before they leave us,) as if they were making ready for their winter's rest. 2. That every species betakes itself to a proper convenient receptacle; some under the waters to the bottoms of ponds; some under the earth below the frosts; some under timber, stone, &c. lying on the ground; some into hollow trees, or under the bark, or in the wood; some into warm and dry places; and some into dry alone.

gested only pretty gross food, must hereafter digest that which is extremely delicate. The blood which circulates in the caterpillar from the hind part towards the head, circulates a contrary way after transformation. New tracheæ are likewise substituted in room of the old ones, and divers organs which were useless to the insect while it lived under the form of a caterpillar, but which are necessary to it under its new state, begin now to develop themselves. Nature, while these operations are performing, causes the insect to fall into a deep sleep, during which she carries on her work uninterrupted by the animal functions. The *corpus crassum*, which is a delicate substance prepared long before, seems to be the principal foundation of the nourishment she distributes into all the parts in
order

But for others that move and act, and need food, it is a prodigious instinct and foresight the Creator hath imprinted on them to lay up sufficient food in summer for the winter's (c) necessities and

(c) There are not many kinds that thus provide their food beforehand. The most remarkable are the *ant* and the *bee*; concerning the first of which *Origen* hath this remark, *viz. De solertiâ formicarum, venturæ hyemî maturè prospicientium, sibi quæque invicem sub onere fessis succurrentium; quòdque fruges arrosas conducunt, ne rursus enascantur, sed per annum alimento sint, non rationem formicarum in causâ debemus credere, sed almam matrem Naturam bruta quoque sic ornantem, ut etiam minimis addat sua quædam ingenia.*—"With respect to the foresight of ants, who make timely provision against the winter, and assist each other when wearied with their burdens, as also their practice of storing up for their food through the year grain which they have gnawed to prevent its vegetation; all these things do not argue a reasoning faculty in the insect, but evince the wisdom and bounty of the Author of Nature in furnishing even the minutest beings with appropriate and useful instincts."—*Orig. cont. Cels. l. 4.*

But as for *wasps*, *hornets*, *humble-bees*, and other *wild bees*, *vespæ ichneumons*, and divers others that carry in materials for nests and food; this is only for the service of their generation, for hatching their eggs and nourishing their young, not for supplies in winter, for they all forsake their nests towards winter, and retire to other quarters, living (I conceive) without food all that time.

order to bring them to perfection. The evaporation of the aqueous humours makes way for the elements of the fibres to approach each other and unite more closely. From thence proceeds an augmentation of the consistence of all the organs.

The

and occasions. And it is very pretty to see with what unwearied diligence all hands are at work for that purpose all the warmer months. Of this the holy Scripture itself gives us an instance in the *ant*, calling that little animal *exceeding wise*, Prov. xxx. 24. And the reason is, ver. 25. *The ants are a people not strong, yet they prepare their meat in the summer.* And therefore Solomon sends the sluggard to this little contemptible creature to learn wisdom, foresight, care, and diligence, Prov. vi. 6, 7, 8. *Go to the ant thou sluggard, consider her ways, and be wise; which having no guide, overseer, or ruler, provideth her meat in the summer, and gathereth her food in the harvest.*

To this Scriptural example give me leave to anticipate and subjoin an observation of the farther great wisdom of this little creature, and that is, their unparalleled *στοργή*, their tenderness, fa-

The little wounds which the rupture of several vessels has occasioned in divers parts of the inside consolidate insensibly. Those parts which had been put into a violent exercise, or whose forms and proportions had been modified to a certain degree, conform themselves gradually to these changes. The liquors which are obliged to pass through new channels take their directions by degrees. Lastly, the vessels which were proper to the caterpillar, some of which occupied a considerable place within it, are effaced or converted into a liquid sediment, which the butterfly voids after having laid aside the sheath of the chrysalis." — *Contemplation de la Nature*, part 9. ch. 12.

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gacity,

gacity, and diligence about their young (*d*). It is very diverting, as well as admirable to see, with what

(*d*) *Hos vermiculos* [formicarum ova vulgò vocatos] *incredibili* τροφήν ἔ' curâ formicæ educant, summamque dant operam, ne vel tantillum, quod spectet eorum vermiculorum educationem atque nutritionem, omittant : quem in finem fere semper eosdem ore circumportant secum, ne ulla eos lædat injuria. In museo meo nonnullas istius generis formicas, vitro terrâ repleto, conclusas cum vermiculis istis adservabam : ibi non sine jucunditate spectabam, quo terra fieret in superficie sicciore, eo profundius formicas cum sætibus suis prorèpere : cùm verò aquam adfunderem, visu mirificum erat, quanto affectu, quantâ sollicitudine, quantâ τροφήν omnem in eo collocarent operam, ut sætus sicciore ἔ' tuto loco reponerent. Sæpiùs vidi, cùm aliquot diebus aquâ caruissent, atque cùm affuso tantillo aque terram illam humectarem, è vestigio à formicis sætus suos eo loci fuisse allatos, quos ibi distinctè conspiciebam moveri atque sugere humorem. Multoties fui conatus, ut eos vermiculos ipse educarem, at semper conatum fefellit eventus : neque ipsas formicarum nymphas alimenti jam non indigas unquam sine ipsis formicis potui fotu artificiali excludere.—
“ Those little worms, commonly called their eggs, the ants tend with incredible affection and care ; anxious to omit nothing that may conduce to their proper rearing and nutrition ; and to that end they most commonly carry them about in their mouths to prevent their meeting with any injury. I have preserved in my museum several of this species of ants in a glass filled with earth, and kept them, together with those little worms. And I have beheld them with much pleasure, when the earth became too dry towards the surface, creep lower down with their young. But when I poured a little water into the glass, it was wonderful to observe with what affection, anxiety, and parental sollicitude they bent all their endeavours to remove their young to a drier and safer situation. I have often remarked, that after they had wanted water for some days, and I poured in a little to moisten the earth, immediately the ants

what affection and care they carry about their young in their mouths, how they expose themselves to the greatest dangers rather than leave their young exposed or forsaken; how they remove them from place to place in their little hills, sometimes to this part, sometimes to that, for the benefit of convenient warmth and proper moisture; and then again withdraw, and guard them against rain and cold. Now that this great wisdom which the Scriptures attribute unto and is discernible in this little animal, is owing only to the instinct or infusions of the great Conservator of the world, is evident,

brought their young towards the place; and I saw them distinctly moving about and sucking up the moisture. I have frequently attempted to rear these little worms myself, but the attempt never succeeded; nor could I ever hatch or bring out those nymphs of the ant by any artificial process without the ants themselves, though they otherwise were in no want of aliment."—*J. Swammerd. Epilog. ad Hist. Insect. p. 153.*

Sir *Edward King*, who was very curious in examining the generation of *ants*, observes their great care and diligence: 1. About their sperm, or true eggs, which is a fine white substance like sugar, which they diligently gather together into a heap when scattered, and on which they lie in multitudes (I suppose by way of incubation). 2. I have observed, saith he, in summer, that in the morning they bring up those of their young (called ant-eggs) towards the top of the bank; so that you may from ten in the morning until five or six in the afternoon find them near the top, for the most part on the south-side the bank. But towards seven or eight at night, if it be cool, or likely to rain, you may dig a foot deep before you can find them. *Philos. Trans. No. 23, or Mr. Lowtharp's Abridg. vol. ii. p. 7 and 9.*

evident, because either this wisdom, thought, and forecast is an act of the animal itself, or of some other being that hath wisdom. But the animal being irrational, it is impossible it can be its own act, but must be derived or received from some wise being. And who? what can that be but the infinite Lord, Conservator, and Governor of all the world?

C H A P. VI.

Of the Care of Insects about their Young.

THE other notable instinct I am to treat of, is the peculiar art and care of the insect-tribe about the preservation of their species. Here I might speak of many things, but I have occasionally mentioned divers of them before under some or other of the general heads, and therefore shall fix only upon two things relating to their special art and care about the production (*a*) of their young, which have not been so particularly spoken to as they deserve.

One thing is their singular providence for their young, in making or finding out such proper receptacles and places for their eggs and seed, as that they may receive the advantage of a sufficient incubation, and that the young, when produced, may have the benefit of proper and sufficient food for their nurture and education till they are able to shift for themselves. It is admirable to see with what diligence and care the several species of insects

(*a*) The doctrine of equivocal generation is at this day so sufficiently exploded by all learned philosophers, that I shall not enter into the dispute, but take it for granted, that all animals spring from other parent animals. If the reader hath any doubt about it, I refer him to *Seigneur Redi de Gen. Insect.* and *Mr. Ray's Wisdom of God*, &c. p. 344. See also before, *book iv. chap. 15. note (a)*.

sects lay up their eggs *, or sperm, in their several proper places, not all in the waters, in wood, or on vegetables; but those whose subsistence is in the waters (*b*), in the water; those to whom flesh is a proper food, in flesh (*c*); those to whom

(*b*) It would be endless to specify the various species of insects, that have their generation in the waters. And therefore I shall only observe of them, 1. That their eggs are always laid up with great care, and in good order; and also, 2. Where proper and sufficient food is. 3. That in their *nympha* state in the waters, they have parts proper for food and motion; and in many, or most of them, very different from what they have in their *mature* state, a manifest argument of the Creator's wisdom and providence. For an instance, see note (*r*).

(*c*) As *Seigneur Redi* was one of the first that made it his business to discard anomalous generation, so he tried more experiments relating to the vermination of serpents, flesh, fish, putrified vegetables, and in short, whatever was commonly known to be the nursery of maggots; more, I say, probably, than any one hath done since. And in all his observations, he constantly found the maggots to turn to *aurelie*, and these into *flies*. But then, saith he, *Dubitare cæpi, utrùm omne hoc vermium in carne genus, ex solo muscarum semine, an ex ipsis putrefactis carnibus oriretur, tantoque magis confirmabar in hoc meo dubio, quanto in omnibus generationibus—sepiùs videram, in carnibus, antequam verminare inciperent, resedisse ejusdem speciei muscas, cujus propago postea nascebatur.*—"I began to doubt whether all those kind of worms in flesh were produced from the *ova* of flies, or from the putrid flesh itself—but I often observed that on flesh, before it began to

* The wolf-spider carries its eggs on its back in a little bag formed of its silk; it cannot be separated from them but by violence, and exhibits the strangest signs of uneasiness when deprived of them; a circumstance the more remarkable, as these animals are distinguished by their ferocity, and a savage appetite of destroying each other.

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whom the fruits (*d*) or leaves of vegetables are food, are accordingly repositied, some in this fruit, some

to exhibit those worms or maggots, flies had settled, of the same species with those of which the maggots were the brood." Upon this he tells us, he put fish, flesh, &c. into pots, which he covered close from the flies with paper, and afterwards (for the free air-sake) with lawn, whilst other pots were left open, with such like flesh, &c. in them; that the flies were very eager to get into the covered pots; and that they produced not one maggot, when the open ones had many. *Fr. Redi de Gener. Insect.*

Among the insects that come from the maggots he mentions, he names *culices*. Now from the most critical observations I have made, I never observed any sort of *gnat* to come from putrified flesh, vegetables, or any other thing he taxeth them with. So that either he means by *culex* some fly that we call not by the name of *gnat*; or else their *gnats* in *Italy* vary in their generation from ours in *England*. For among above thirty, near forty, distinct species of *gnats* that I have observed about the place where I live, I never found any to lay their eggs in flesh, fish, &c. but the largest sort, called by *Aldrovand*, *culices maximi*, by *Swammerdam*, *tipulæ terrestres*, lay their eggs in meadows, &c. under the grass; one of the larger middle sort, in dead beer, yeast, &c. lying on the tops, or in the leaks of beer-barrels, &c. and all the rest (as far as ever I have observed) lay and hatch in the waters, as in *note (r)*.

The generation of the second of these being akin to some of the foregoing instances, and a little out of the way, may deserve a place here. This *gnat* lays its eggs commonly in dead beer, &c. as I said, and probably in vinegar, and other such liquors. Some time after which, the maggots are so numerous, that the whole liquor stirreth as if it was alive; being full of maggots, some larger, some smaller; the larger are the offspring of our *gnat*; the smaller, of a small dark-coloured fly, tending to reddish; frequent in cellars, and such obscure places. All these maggots turn to *aurelia*, the larger of which, of a tan-colour, turn to our *gnat*. This *gnat* is of the unarmed kind, having no spear in its mouth. Its head is larger than of the common *gnats*,
a longer



1. The *Eruca* or maggot which feeds on the leaves of the Plum-tree & hawthorn.
 2. The chrysalis or aurelia of the same insect. 3. The same chrysalis on a hawthorn branch. 4. The white butterfly produced from that chrysalis. 5. A butterfly emerging from its chrysalis state. 6. Part of a butterfly's wing shewing the arrangement of its feathers. 7. Various feathers of different butterfly wings.
 8. The Mole-cricket, or *Gryllotalpa*.

some on this tree (*e*), some on that plant (*f*), some on another, and another; but constantly the same family

a longer neck, short-jointed *antennæ*, spotted wings, reaching beyond its slender *alvus*; it is throughout of a brown colour, tending to red, especially in the female: the chief difference between the male and female is, (as in other *gnats*, yea, most insects,) the male is less than the female, and hath a slenderer belly, and its *podex* not so sharp as the female's is.

(*d*) The insects that infest fruits, are either of the *ichneumon-fly* kind, or *phalænæ*. Plumbs, pease, nuts, &c. produce some or other *ichneumon-fly*. That generated in the *plumb* is black, of a middle size, its body near three-tenths of an inch long, its tail not much less, consisting of three bristles, wherewith it conveys its eggs into fruits: its *antennæ*, or horns, long, slender, recurved; its belly longish, tapering, small towards the *thorax*; legs reddish; wings membranaceous, thin and transparent, in number four, which is one characteristic of the *ichneumon-fly*.

The *pease ichneumon fly*, is very small, wings large, reaching beyond the *podex*; *antennæ* long, *alvus* short, shaped like an heart, with the point towards the *anus*; it walketh and flieth slowly. No tail appears, as in the former; but they have one lieth hidden under the belly, which they can at pleasure bend back to pierce pease when they are young and tender, and other things also, as I have reason to suspect, having met with this (as indeed the former two) in divers vegetables.

Pears and *apples* I could never discover any thing to breed in, but only the lesser *phalænæ*, about four-tenths of an inch long, whitish underneath; greyish-brown above (dappled with brown spots, inclining to a dirty red) all but about a third part at the end of the wings, which is not grey, but brown, elegantly striped with wavy lines, of a gold colour, as if gilt; its head is small, with a tuft of whitish-brown in the forehead; *antennæ* smooth, moderately long. The *aurelia* of this moth is small, of a yellowish brown. I know not what time they require for their generation out of boxes; but those I laid up in *August* did not become moths before *June* following.

(*e*) There are many of the *phalænæ* and *ichneumon-fly* tribes that have their generation on the leaves or other parts of trees

family on the same tree or plant, the most agreeable to that family. And as for others that require a constant and greater degree of warmth, they are accordingly provided by the parent animal with some place in or about the body of other animals *,
 some

and shrubs, too many to be here reckoned up. The *oak* hath many very beautiful *phalænæ*, bred in its convolved leaves, white, green, yellow, brown, spotted prettily, and neatly dappled, and many more besides; and its buds afford a place for cases, and balls of various sorts, as shall be shewn hereafter; its leaves expanded, minister to the germination of globular, and other spheroidal balls, and flat *thecæ*, some like hats, some like buttons excavated in the middle; and divers others such like repositories, all belonging to the *ichneumon-fly* kind. And not only the *oak*, but the *maple* also, the *white-thorn*, the *briar*, *privet*, and indeed almost every tree and shrub.

(*f*) And as trees and shrubs, so plants have their peculiar insects. The *white butterfly* lays its voracious offspring on cabbage-leaves; a very beautiful reddish ocellated one, its no less voracious black offspring of an horrid aspect, on the leaves of nettles; as also doth a very beautiful, small, greenish *ichneumon-fly*, in cases on the leaves of the same plant: and to name no more (because it would be endless) the beautiful *ragwort-moth*, whose upper wings are brown, elegantly spotted with red, and under wings edged with brown; these, I say, provide for their golden ringed *crucæ* upon the *rag-wort plant*.

* The following singular fact is taken from Mr. Adams's Microscopical Essays, a work of very great merit, and well deserving the attention of the curious. He relates it as the observation of an ingenious naturalist. "As I was observing one day some caterpillars which were feeding voluptuously on a cabbage leaf, my attention was attracted towards a part of the plant, about which a little fly was buzzing on its wing, as if deliberating where to settle: I was surprised to see the herd of
 caterpillars,

some in the feathers of birds (*g*); some in the hair of beasts (*b*); some in the very scales of fishes (*i*);
some

(*g*) Many, if not most sorts of birds, are infested with a distinct kind of *lice*, very different from one another in shape, size, &c. For figures and descriptions of them, I shall refer to *Seigneur Redi of Insects*. See also *Moufet*, l. 2. c. 23. These lice lay their nits among the feathers of the respective birds, where they are hatched and nourished; and as *Aristotle* saith, would destroy the birds, particularly *pheasants*, if they did not dust their feathers. *Loco infr. citat.*

(*b*) And as birds, so the several sorts of beasts have their peculiar sorts of lice; all distinct from the two sorts infesting man: only the *ass*, they say, is free, because our *Saviour* rode upon one, as some think; but I presume it is rather according to *Pliny's* remark, l. 11. c. 33. or *Arist. Hist. Animal.* l. 3. c. 31. who saith, *Quibus pilus est, non carent eodem [pediculo] excepto asino, qui non pediculo tantum, verum etiam redivio immunis est.*—
“ Those animals which have hair, have all lice, except the
ass,

caterpillars, creatures of twenty times its size, endeavouring in an uncouth manner, by various contortions of the body, to get out of its way, and more so whenever the fly poised on the wing, as if going to drop: at length the creature made its choice and seated itself on the back of one of the largest and fairest of the cluster; it was in vain the unhappy reptile endeavoured to dislodge the enemy. Its anguish now seemed intolerable, and I soon found it was in consequence of the wounds or strokes given by the fly. At every wound the poor caterpillar wreathed and twisted its whole frame, endeavouring to disengage itself by shaking off the enemy, sometimes aiming its mouth towards the place, but it was all in vain; its little but cruel tormentor kept its place. When it had inflicted 30 or 40 of these wounds, it took its flight with a visible triumph: in each of these wounds the little fly had deposited an egg. I took the caterpillar home with me to observe the progress of the eggs which were thus placed in its body, taking care to give it a fresh supply

some in the nose (*k*); some in the flesh (*l*); yea, some in the very bowels (*m*); and inmost recesses of

as, who is not only free from them, but likewise from the tick."—And a little before, speaking of those in men, he shews what constitutions are most subject to them, and instanceth in *Alcman* the poet, and *Pherecydes Syrius* that died of the *pthiriasis*, or lousy disease. For which foul distemper, if medicines are desired, *Moufet de Insect*, p. 262. may be consulted. Who in the same page hath this observation, *Animadverterunt nostrates*—*ubi Afores insulas à tergo reliquerint, pediculos confestim omnes tabescere: atque ubi eas reviserint, iterum innumeros alios subito oriri.*—"Our countrymen have observed that on leaving the islands of the Azores, all the lice with which they were infested suddenly died; but immediately on returning to those islands, they had them in great numbers."—Which observation is confirmed by Dr. *Stubs*. Vide *Lowth. Abridg.* vol. 3. p. 558. And many seamen have told me the same.

(*i*) Fishes, one would think, should be free from lice, by reason they live in the waters, and are perpetually moving in, and brushing through them; but yet they have their sorts too.

Besides

supply of leaves from time to time. It recovered to all appearance from the wounds it had received; and from that time, for the space of four or five days, seemed to live comfortably, feeding voraciously. The eggs were all hatched into small oblong voracious worms, which fed from the moment of their appearance on the flesh of the caterpillar, in whose body they were inclosed, and seemingly without wounding the organs of respiration or digestion; and when they had arrived at their full growth, they eat their way out of the sides of the animal, at the same time destroying it. The caterpillar, thus attacked by the larva of the ichneumon, never escapes; its destruction is infallible; but then its life is not taken away at once; the larva, while it is feeding thereon, knows how to spare the parts that are essential to its life, because its own is at that time tied up in that of the caterpillar."

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of the bodies of man and other creatures (*n*): and as for others to whom none of these methods are proper,

Besides which, I have frequently found great numbers of long slender worms in the stomachs, and other parts of fish, particularly *codfish*, especially such as are poor; which worms have worked themselves deeply into the coats and flesh, so that they could not easily be gotten out: so *Aristotle* saith of some fishes, *Ballero & tilloni lumbricus innascitur, qui debilitat, &c. chalcis vitio infestatur diro, ut pediculi sub branchiis innati quàm multi interimant.*—"A small worm grows upon the bleak and the tillo, which weakens them; and the herring is subject to a fatal disorder, for many of them are killed by a species of lice which grow under the gills."—*Hist. An.* l. 8. c. 20.

(*k*) Of insects bred in the nose of animals, those in the nostrils of *sheep* are remarkable. I have myself taken out not fewer at a time than twenty or thirty rough maggots, lying among the *laminae* of the nostrils. But I could never hatch any of them, and so know not what animal they proceed from: but I have no great doubt, they are of the *ichneumon-fly* kind; and not improbably of that with a long tail, called *trisetta*, whose three bristles seem very commodious for conveying its eggs into deep places.

I have also seen a rough whitish maggot, above two inches within the *intestinum rectum* of horses, firmly adhering thereto, that the hard dung did not rub off. I never could bring them to perfection, but suspect the *side-fly* proceeds from it.

(*l*) In the backs of *cows*, in the summer-months, there are maggots generated, which in *Essex* we call *wornils*; which are first only a small knot in the skin; and I suppose no other than an egg laid there by some insect. By degrees these knots grow bigger, and contain in them a maggot lying in a purulent matter: they grow to be as large as the end of one's finger, and may be squeezed out at a hole they have always open: they are round and rough, and of a dirty white. With my utmost endeavour and vigilance, I could never discover the animal they turn into; but as they are somewhat like, so may be the same as those in the note before.

proper, but make themselves nests by perforations in the earth, in wood, or combs they build, or such

In *Persia* there are very long slender worms, bred in the legs, and other parts of men's bodies, six or seven yards long.

In *Philos. Trans.* Mr. *Dent* and Mr. *Lewis* relate divers examples of worms taken out of the tongue, gums, nose, and other parts, by a woman at *Leicester*, which they were eye-witnesses of. These, and divers others mentioned in the *Transactions*, may be seen together in Mr. *Lowthorp's Abridg.* vol. 3. p. 132.

*Narrat mihi vir fide dignus—Casp. Wendlandt—se in Polonia, puero cuidam russo duorum annorum, vermiculum album è palpebrâ extraxisse,—magnitudinis erucæ.—Similem fere huic casum mihi [Schulzio] & D. Segero narravit hoc, anno 1676. chirurgus noster Ant. Statlender, qui cuidam puero, ex aure, extraxit vermiculum talem, qualis in nubibus avellanis perforatis latitare solet, sed paulò majorem, coloris albißimi; alteri minores 5 ejusdem generis similiter ex aure: omnes aliquot horas supervixerunt—vermiculos adhuc viventes oculis nostris vidimus.—“ I was told by a person to whose word I give implicit credit, (Caspar Wendlandt,) that he had extracted a white worm of the bigness of a grub, out of the eye-brow of a boy of two years old, the son of a labourer in *Poland*. A similar fact was told to myself and Segerus by our surgeon Ant. Statlender, namely, that he had extracted from a boy's ear a worm similar to those found in rotten filberds, but a little larger, and very white; as also five others of a smaller size likewise from the ear. The worms lived for some hours, and we ourselves saw them alive.”—*Ephem. Germ.* tom. 2. Obs. 24. ubi vermiculi icon. Many other instances may be met with in the same volume. Obs. 147, 148, 154.*

The worms in *deer* are mentioned often among antient writers. *Aristotle* saith, Σκώληκας μέντοι πάντες ἔχουσιν, ἐν τῇ κεφαλῇ ζῶντας, &c. They [deer] all have live worms in their heads; bred under the tongue, in a cavity near the vertebra, on which the head is placed; their size not less than of the largest maggots; they are bred all together, in number about twenty. *Aristot. Hist. Animal.* l. 2. c. 15.

such like ways; 'tis admirable to see with what labour and care they carry in, and seal up provisions, that

To these examples may be added the generation of the *ichneumon-fly* in the bodies of caterpillars, and other *nymphæ* of insects. In many of which, that I have laid up to be hatched in boxes, instead of *papilios*, &c. as I expected, I have found a great number of small *ichneumon-flies*, whose parent animal had wounded those *nymphæ*, and darted its eggs into them, and so made them the foster-mother of its young. More particulars of this way of generation may be seen in the great Mr. *Willughby's* Observations in *Philos. Trans.* No. 76. But concerning the farther generation of this insect, I have taken notice of other particulars in other places of these notes.

(m) The animals ordinarily bred in the stomach and guts, are the three sorts of worms called *lati*, *teretes*, and *ascarides*; concerning which, it would be irksome to speak in particular, and therefore I shall refer to *Moufet*, l. 2. c. 31, 32, 33. Dr. *Tyson's* Anatomy of them in Mr. *Lowthorp's* Abridg. v. 3. p. 121. *Seigneur Redi's* Obs. and others that have written of them.

And not only worms, but other creatures also are said to be found in the stomach; instances of which are so innumerable, that I shall only select a few related by persons of the best credit; and first of all, by some of our own countrymen. Dr. *Lifter* (whose credit and judgment will hardly be questioned) gives an account of true *caterpillars*, vomited up by a boy of nine years old; and another odd animal by a poor man. Mr. *Jessop* (another very judicious, curious, and ingenious gentleman) saw *hexapods* vomited up by a girl; which *hexapods* lived and fed for five weeks. See *Lowth. ib.* p. 135.

And to foreigners, it is a very strange story (but attested by persons of great repute) of *Catharina Geileria*, that died in Feb. 1662, in the hospital of *Altenburg* in *Germany*, who for twenty years voided by vomit and stool toads and lizards, &c. *Ephemer. Germ.* tom. 1. Obs. 103. See also the 109th observation of a kitten bred in the stomach, and vomited up; of whelps also, and other animals, bred in like manner. But I fear a stretch of fancy

that serve both for the production of their young, as also for their food and nurture when produced (o).

The

fancy might help in some of those last instances, in those days when spontaneous generation was held, when the philosophers seem to have more slightly examined such appearances than now they do. But for the breeding of *frogs* or *toads*, or *lacertæ aquatica* in the stomach, when their spawn happeneth to be drank, there is a story in the second volume of the *Ephem. Germ. Obs.* 56. that favours it, viz. *In the year 1667, a butcher's man going to buy some lambs in the spring, being thirsty, drank greedily of some standing water, which a while after caused great pains in his stomach, which grew worse and worse, and ended in dangerous symptoms. At last he thought somewhat was alive in his stomach, and after that, vomited up three live toads; and so recovered his former health.*

Such another story Dr. *Sorbait* tells, and avoucheth it seen with his own eyes, of one that had a toad came out of an abscess, which came upon drinking foul water. *Obs.* 103.

(n) Not only in the guts, and in the flesh; but in many other parts of the body, worms have been discovered. One was voided by urine, by Mr. *Mat. Milford*, supposed to have come from the kidneys. *Lowth, ib.* p. 135. More such examples *Mouffet* tells of. *Ibid.* So the *vermes cucurbitini* are very common in the vessels in sheep's livers: and Dr. *Lijfer* tells of them, found in the kidney of a dog, and thinks that the snakes and toads, &c. said to be found in animals bodies, may be nothing else. *Lowth, ib.* p. 120. Nay, more than all this; in Dr. *Bern Verzascha's* sixth Observation, there are divers instances of worms bred in the brain of man. One, a patient of his, troubled with a violent headache, and an itching about the nostrils, and frequent sneezing; who, with the use of a sneezing-powder, voided a worm, with a great deal of mucus from his nose. A like instance he gives from *Bartholine*, of a worm voided from the nose of O. W. which he guesseth was the famous *Olaus Wormius*: another, from a country-woman of *Dietmarß*; and others in *Tulpius*, *F. Hildanus*, *Schenekius*, &c. These worms he thinks are undoubtedly bred in

The other piece of remarkable art and care about the production of their young, is their curiosity and neatness in repositing their eggs, and in their nidification.

As

in the brain: but what way they can come from thence, I cannot tell. Wherefore I rather think, they are such worms as are mentioned in *note (k)*, and even that worm that was actually found in the brain of the *Paris girl* (when opened) I guess might be laid in the *laminæ* of the nostrils, by some of the *ichneumon*, or other insect kind, and might gnaw its way into the brain, through the *os cribiforme*. Of this he tells us from *Bartholine*, *Tandem cùm tabida obiisset, statim aperto cranio præsentem medicum totam cerebelli substantiam, quæ ad dexterum vergit, à reliquo corpore sejunctam, nigrâque tunica involutam deprehenderunt: hæc tunica rupta, latentem vermem vivum, & pilosum, duobus punctis splendidis loco oculorum prodidit, ejusdem fere molis cum reliquâ cerebri portione, qui duarum horarum spacio supervixit.*—"At length having died consumptive, and her scull being laid open, the physicians observed all the substance of the cerebellum on the right side separated from the rest of the brain, and covered with a thick tegument. When this covering was removed, they observed a live worm, hairy, and two shining points in the place of eyes. It was almost equal in size to all the rest of the brain; and it lived for the space of two hours."—*B. Verzas. Obs. Medicæ*, p. 16.

Hildanus tells us such another story, viz. *Filius Theod. auct der Roulen, avunculi mei, diuturno vexabatur dolore capitis.*—*Deinde febriculâ & sternutatione exortâ, ruptus est abscessus circa os cribosum—& vermis prorepsit.*—"The son of my uncle Theod. auct der Roulen had been troubled with a constant pain in his head. A fever came on attended with sneezing; and an abscess formed about the *os cribosum* having burst, a worm crept out."—By his figure of it, the maggot was an inch long, and full of bristles. *Fabri Hildan. Cent. i. Obs.*

Galenus Wierus, (physician to the *Princ. Jul. & Cleve*,) he saith, told him, that he had, at divers times, found worms in the gall-bladder in persons he had opened at *Dusseldorp*. *Id. ib. Obs. 60.*
(o) See before, *book iv. chap. 13. note (c)*.

As to the first of which, we may observe, that great curiosity and nice order is generally observed by them in this matter. You shall always see their eggs laid carefully and commodiously up (*p*). When upon the leaves of vegetables, or other material on land, always glued thereon with care, with one certain end lowermost, and with handsome juxtapositions (*q*). Or if in the waters, in neat and beautiful rows oftentimes, in that spermatic, gelatine matter, in which they are reposed, and that matter carefully tied and fastened in the waters, to prevent its dissipation (*r*), or if made to float, so carefully

(*p*) Some insects lay up their eggs in clusters, as in holes of flesh, and such places, where it is necessary they should be crowded together; which, no question, prevents their being too much dried up in dry places, and promotes their hatching. But,

(*q*) As for such as are not to be clustered up, great order is used. I have seen upon the posts and sides of windows, little round eggs, resembling small pearl, which produced small hairy caterpillars, that were very neatly and orderly laid. And to name no more, the *white butterfly* lays its neat eggs on the cabbage leaves in good order, always gluing one certain end of the egg to the leaf. I call them neat eggs, because if we view them in a microscope, we shall find them very curiously furrowed, and handsomely made and adorned.

(*r*) By reason it would be endless to specify the various generation of insects in the water, I shall therefore (because it is little observed) take *Pliny's* instance of the *gnat*, a mean and contemned animal, but a notable instance of Nature's work, as he saith.

The first thing considerable in the generation of this insect is (for the size of the animal) its vast *spawn*, being some of them
above

carefully spread and poised, as to swim about with all possible artifice.

And

above an inch long, and half a quarter diameter; made to float in the waters, and tied to some stick, stone, or other fixed thing in the waters, by a small stem or stalk. In this gelatine, transparent spawn, the eggs are neatly laid; in some spawns in a single, in some in a double spiral line, running round from end to end, as in *fig. 3* and *4*, and in some transversely, as *fig. 5*, Plate H.

When the eggs are by the heat of the sun and warmth of the season hatched into small maggots, these maggots descend to the bottom, and by means of some of the gelatine matter of the spawn (which they take along with them) they stick to stones and other bodies at the bottom, and there make themselves little cases or cells, which they creep into and out of at pleasure, until they are arrived to a more mature *nympha-state*, and can swim about here and there, to seek for what food they have occasion; at which time they are a kind of red-worms, above half an inch long, as in *fig. 6*, Plate H.

Thus far this mean insect is a good instance of the Divine Providence towards it. But if we farther consider, and compare the three states it undergoes after it is hatched, we shall find yet greater signals of the Creator's management, even in these meanest of creatures. The three states I mean, are its *nympha-vermicular* state, its *aurelia*, and *mature-state*, all as different as to shape and accoutrements, as if the insect was three different animals. In its *vermicular-state*, it is a red-maggot, as I said, and hath a mouth and other parts accommodated to food: in its *aurelia-state* it hath no such parts, because it then subsists without food; but in its *mature, gnat-state*, it hath a curious well-made spear, to wound and suck the blood of other animals. In its *vermicular-state*, it hath a long worm-like body, and something analogous to fins or feathers, standing erect near its tail, and running parallel with the body, by means of which resisting the waters, it is enabled to swim about by curvations, or flapping its body, sideways, this way and that, as in *fig. 7*, Plate H.

And as to their other faculty, that of nidification, whether it be exerted by boring the earth or wood, or building themselves cells (*s*), or spinning and weaving themselves cases and webs, it is all a wonderful faculty of those poor little animals, whether we consider their parts wherewith they work, or their work itself. Thus those who perforate the earth, wood, or such like, they have their legs, feet, mouth, yea, and whole body accommodated to that service; their mouth exactly formed to gnaw those handsome round holes, their feet as well made to scratch and bore (*t*), and their body handsomely turned and fitted to follow. But for such as build or spin themselves nests, their art justly bids defiance to the most ingenious artist among men, so much as tolerably to copy the nice geometrical combs of some (*u*), the earthen cells of

But in its *aurelia*-state, it hath a quite different body, with a *club-head*, (in which the head, *thorax*, and wings of the *gnat* are inclosed,) a slender *abous*, and a neat *finny tail*, standing at right angles with the body, quite contrary to what it was before; by which means, instead of easy flapping sideways, it swims by rapid, brisk jirks, the quite contrary way; as is in some measure represented in *fig. 8*. But when it becomes a *gnat*, no finny tail, no club-head, but all is made in the most accurate manner for flight and motion in the air, as before it was for the waters.

(*s*) See *book iv. chap. 13. notes (n), (o)*.

(*t*) Thus the mouths and other parts of the *ichneumon-wasps* in *book iv. chap. 13. note (c)*. So the feet of the *Gryllotalpa*, *ibid. note (s)*. See *Plate I.*

(*u*) See the last cited places, *note (o)*.

of others *, or the webs, nets, and cases (*w*) woven by others. And here that natural glue (*x*) which
their

(*w*) Of the textrine art of the *spider*, and its parts serving to that purpose, see the last cited place, *note* (*x*).

Besides these, *caterpillars*, and divers other insects, can emit threads or webs for their use. In this their *nympha-state*, they secure themselves from falling, and let themselves down from the boughs of trees, and other high places, with one of these threads. And in the cases they weave, they secure themselves in their *aurelia-state*.

And not only the offspring of the *phalena-tribe*, but there are some of the *ichneumon-fly* kind also endowed with this textrine art. Of these I have met with two sorts; one that spun a milk-white, long, round, filken web, as big as the top of one's finger, not hollow within, as many are, but filled throughout with silk. These are woven round bents, stalks of ribwort, &c. in meadows. The other is a lump of many yellow, filken cases, sticking confusedly together on posts, under coleworts, &c. These webs contain in them small whitish maggots, which turn to a small black *ichneumon-fly*, with long capillary *antennae*; tan-coloured legs; long wings reaching beyond their body, with a black spot near the middle; the *alvus* like an heart; and in some, a small setaceous tail. Some of these flies were of a shining, beautiful green colour. I could not perceive any difference, at least not specifical, between the flies coming from those two productions.

(*x*) I have often admired how *wasps*, *hornets*, *ichneumon-wasps*, and other insects that gather dry materials for building their nests, have found a proper matter to cement and glue their combs, and line their cells; which we find always sufficiently context
and

* Mr. Sauvage discovered a species of spider which burrows in the earth like a rabbit, making a hole one or two feet deep of a regular diameter, and sufficiently large to allow of the animal's

their bodies afford some of them to consolidate their work, and combine its materials together, and which in others can be darted out at pleasure, and spun and woven by them into filken balls (y) or webs.

and firm. But, in all probability, this useful material is in their own bodies ; as it is in the *tinea vestivora*, the *cadew-worm*, and divers others. *Goedart* observes of his *Eruca*, Num. xx. 6. that fed upon *fallow-leaves*, that it made its cell of the comminuted leaves, glued together with its own spittle, *Hæc pulveris aut arenæ instar comminuit, ac pituitoso quodam sui corporis succo ita maceravit, ut inde accommodatum subeundæ mutationi instanti locum sibi extruxerit. Domuncula hæc à communi salicum ligno nihil differre videbatur, nisi quòd longè esset durior, adeò ut cultro vix dirumpi posset.*—" It gnawed them as small as dust or sand, and so macerated them with a certain phlegmy juice from its own body, as to be able to form them into a most convenient receptacle for itself under its subsequent change. This little house differed nothing in appearance from the common wood of the fallow, but it was harder, so that it could scarcely be cut with a knife."

(y) *An ingenious gentlewoman of my acquaintance, wife to a learned physician, taking much pleasure to keep silk-worms, had once the curiosity to draw out one of the oval cases which the silk-worm spins—into all the filken wire it was made up of, which, to the great wonder as well of her husband as herself, appeared to be, by measure, a great deal above 300 yards, and yet weighed but two grains and an half.* Boyle Subtil. of Effluv. ch. 2.

moving in it with ease. It lines the whole with a web, which answers two purposes ; first, to prevent the earth from falling in and closing on its habitation ; and secondly, that by means of the threads of this web, the least motion of an insect at the mouth, or in any part of the tube, may be immediately perceived by the spider at the bottom, who, upon such warning, rushes out with great rapidity to seize his prey.

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webs. I say, this so peculiar, so serviceable a material, together with the curious structure of all parts ministering to this textrine power, as mean a business as it may seem, is such as may justly be accounted among the noble designs and works of the infinite Creator and Conservator of the world.

In the last place, there is another prodigious faculty, art, cunning, or what shall I call it? that others of those little animals have, to make even Nature itself serviceable to their purpose; and that is, the making the vegetation and growth of trees and plants *, the very means of the building of their little nests and cells (z), such as are the galls and balls

(z) Since my penning this, I have met with the most sagacious *Malphigi's* account of *galls*, &c. and find his descriptions to be exceedingly accurate and true, having traced myself many of the productions he hath mentioned. But I find *Italy* and *Sicily* (his book *de Gallis* being published long after he was made Professor of *Messina*) more luxuriant in such productions than *England*, at least, than the parts about *Upminster* (where I live) are. For many, if not most of those about us, are taken notice of by him, and several others besides that I never met with; although I have for many years as critically observed all the excrescences and other morbid tumors of vegetables, as is almost possible, and do believe that few of them have escaped me.

As

* Insects are found no where so numerous as in trees and plants. They dwell 1, in the roots; 2, in the wood; 3, in the leaves and in the galls which grow upon the leaves and branches; 4, in the flowers; 5, in the fruits and grains.

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balls found on the leaves and branches of divers vegetables, such as the oak, the willow (*aa*), the briar, and some others.

Now

As to the method how those *galls* and *balls* are produced, the most simple, and consequently the most easy to be accounted for, is that in the gems of oak, which may be called *squamous oak-cones*, *capitula squamata*, in *Malpighi*; Plate K, *fig. 4*; whose description not exactly answering our *English cones* in divers respects, I shall therefore pass his by, and shew only what I have observed myself concerning them.

These *cones* are, in outward appearance, perfectly like the gems, only vastly bigger; and indeed they are no other than the gems, increased in bigness, which naturally ought to be pushed out in length: the cause of which obstruction of the vegetation is this: into the very heart of the young tender gem or bud (which begins to be turgid in *June*, and to shoot towards the latter end of that month, or beginning of the next; into this, I say) the parent insect thrusts one or more eggs, and not perhaps without some venomous ichor therewith. This egg soon becomes a maggot, which eats itself a little cell in the very heart or pith of the gem, which is the rudiment of the branch, together with its leaves and fruit, as shall be hereafter shewn. The branch being thus wholly destroyed, or at least its vegetation being obstructed, the sap that was to nourish it is diverted to the remaining parts of the bud, which are only the scaly teguments; which by these means grow large and flourishing, and become a covering to the insect-case, as before they were to the tender branch and its appendage.

The *case* lying within this cone is at first but small, as the maggot included in it is, but by degrees, as the maggot increaseth, so it grows bigger, to about the size of a large white pea, long and round, resembling the shape of a small acorn.

The *insect* itself is (according to the modern insectologists) of the *ichneumon-fly* kind; with four membranaceous *wings*, reaching a little beyond the body, articulated *horns*, a large *thorax*, bigger than the belly; the *belly* short and conical; much like the heart

Now this is so peculiar an artifice, and so far out of the reach of any mortal understanding, wit, or power, that if we consider the matter, with some of its circumstances, we must needs perceive manifest design, and that there is the concurrence of some great and wise Being, that hath, from the beginning, taken care of and provided for the animal's good: for which reason, as mean as the instance may seem, I might be excused, if I should
enlarge

heart of animals; the *legs* partly whitish, partly black. The *length* of the body from head to tail, about $\frac{2}{10}$ of an inch; its *colour* a very beautiful shining green, in some tending to a dark copper-colour. Figures both of the cones, cases, and insects, may be seen among *Malpighi's* cuts of galls, *tab.* 13. and *tab.* 20. *fig.* 72.; which *fig.* 72. exhibits well enough some others of the *gall-insects*, but its *thorax* is somewhat too short for ours. See Plate K.

(*aa*) Not only the willow, and some other trees, but plants also, as *netiles*, *ground-ivy*, &c. have cases produced on their leaves by the injection of the eggs of an *ichneumon-fly*. I have observed those cases always to grow in, or adjoining to some rib of the leaf, and their production I conceive to be thus, *viz.* The parent-insect, with its stiff setaceous tail, terebrates the rib of the leaf, when tender, and makes way for its egg into the very pith or heart thereof, and probably lays in therewith some proper juice of its body, to pervert the regular vegetation of it. From this wound arises a small excrescence, which (when the egg is hatched into a maggot) grows bigger and bigger, as the maggot increases, swelling on each side the leaf between the two membranes, and extending itself into the parenchymous part thereof, until it is grown as big as two grains of wheat. In this case lies a small, white, rough maggot, which turns to an *aurelia*, and afterwards to a very beautiful green small *ichneumon-fly*.

enlarge upon its particulars. But two or three hints shall suffice.

In the first place, it is certain that the formation of those *cases* and *balls* quite exceeds the cunning of the animal itself; but it is the act partly of the vegetable*, and partly of some virulency (or what shall I call it?) in the juice, or egg, or both, repositd on the vegetable by the parent animal (*bb*). And as this virulency is various, ac-
cording

(*bb*) What I suspected myself, I find confirmed by *Malpighi*, who, in his exact and true description of the fly bred in the oaken galls, saith, *Non sat fuit Naturæ tam miro artificio terebram seu limam condidisse; sed inflicto vulnere, vel excitato foramine infundendum exinde liquorem intra terebram condidit: quare fractâ per transversam muscarum terebrâ frequentissimè, vivente animali, guttæ aliquot diaphani humoris effluunt.*—“Nature was not content alone to frame, with the most exquisite skill, that instrument which the gall-fly possesses for piercing and filing the wood; but she repositd within the instrument a liquor to be infused into the wound; for when the instrument is broken transversely, and the animal is still alive, some drops of a pellucid liquor are observed to flow out.”—And a little after he confirms, by ocular observation, what he imagined before, viz. *Semel prope Junii finem vidi muscam, qualem superius delineavi, insidentem quercina*

* If the embryo or egg be deposited on a leaf, the leaf is observed to bend as if purposely to enwrap it and defend it from cold and other injuries. If the egg is deposited in the body of an animal or plant, they in like manner accommodate themselves to its wants and necessities, and furnish a tumour which serves it for a nidus, and besides, like an uterus, supplies it with nourishment; and, if deposited in the body of an insect, the creature provides for the future destination or its young charge with all the tender care of a parent, and then dies. See *Encyclop. Britan. Art. Physiology.*

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cording to the difference of its animal, so is the form and texture of the cases and balls excited thereby; some being hard shells (*cc*), some tender balls,

cina gemma, adhuc germinanti; hærebat etenim foliolo stabili ab apice hiantis gemma erumpenti; & convulso in arcum corpore, terebram evaginabat, ipsamque tensam immittebat; & tumefacto ventre circa terebræ radicem tumorem excitabat, quem interpolatis vicibus remittebat. In folio igitur, avulsâ muscâ, minima & diaphana reperi ejecta ova, simillima iis, quæ adhuc in tubis supererant. Non licuit iterum idem admirari spectaculum, &c.—“Once (about the latter end of June) I observed one of those flies I have been describing sitting on an oak-bud which was still germinating. It stuck to the little leaf which appeared at the point of the bud, and having bent its body like a bow, it thrust out its borer and darted it into the leaf; and swelling out its belly at that place whence the borer issues, it alternately thrust it backwards and forwards. When the fly was pulled off, I found several small transparent eggs similar to those that yet remained in the tube. I had no opportunity of admiring the same spectacle a second time.”

Somewhat like this, which *Malpighi* saw, I had the good fortune to see myself once some years ago; and that was the beautiful shining oak-ball *ichneumon* strike its *terebra* into an oak-apple divers times, no doubt to lay its eggs therein. Plate K, *fig. 9*. And hence I apprehend we see many *vermicules* towards the outside of many of the oak-apples, which I guess were not what the primitive insects laid up in the gem from which the oak-apple had its rise, but some other supervenient additional insects laid in after the apple was grown, and whilst it was tender and soft.

(*cc*) The *Aleppo* galls, wherewith we make ink, may be reckoned of this number, being hard, and no other than cases of insects which are bred in them; who, when come to maturity, gnaw their way out of them; which is the cause of those little holes observable in them. Of the insects bred in them, see *Philos. Transact.* No. 245. Of this number also are those little smooth cases, as big as large pepper-corns, growing close

[balls (*dd*), some scaly (*ee*), some smooth (*ff*), some hairy (*gg*), some long, some round, some conical,

to the ribs under oaken leaves, globous but flattish; at first touched with a blushing red, afterwards growing brown, hollow within, and an hard thin shell without. In this lieth commonly a rough white maggot, which becomes a little long-winged black *ichneumon-fly*, that eats a little hole in the side of the gall, and so gets out.

(*dd*) For a sample of the tender balls, I shall choose the globous ball, as round and some as big as small musket-bullets, growing close to the ribs under oaken leaves, of a greenish yellowish colour, with a blush of red; their skin smooth, with frequent risings therein. See Plate K, *fig.* 1, 2, 3. Inwardly they are very soft and spongy; and in the very centre is a case with a white maggot therein, which becomes an *ichneumon-fly*, *fig.* 5., not much unlike the last. As to this gall, there is one thing I have observed somewhat peculiar, and I may say providential, and that is, that the fly lies all the winter in these balls in its infantile state, and comes not to its maturity till the following spring. In the autumn and winter, these balls fall down with their leaves to the ground, and the insect inclosed in them is there fenced against the winter frosts, partly by other leaves falling pretty thick upon them, and especially by the thick, parenchymous, spongy walls afforded by the galls themselves.

Another sample shall be the large *oak-balls*, called *oak-apples*, growing in the place of the buds, whose generation, vegetation, and figure may be seen in *Malpigh. de Gallis*, p. 24. and *tab.* 10. *fig.* 33, &c. Out of these galls, he saith, various species of flies come, but he names only two, and they are the only two I ever saw come out of them: *Frequenter* (saith he) *subnigræ sunt muscæ brevi munitæ terebrâ. Inter has aliquæ observantur aureæ, levi viridis tincturâ suffusæ, oblongâ pollentes terebrâ.*—"These flies are frequently observed of a blackish colour, and furnished with a short borer. A few appear of a golden colour suffused with a light tincture of green, and these have an oblong borer." These two differently-coloured flies I take to be no other than male

and

conical, &c. (*bb*). And in the last place, let us add, that those species of insects are all endowed with

and female of the same species. I have not observed tails (which are their *terebra*) in all, as *Malpighi* seems to intimate: perhaps they were hid in their *theca*, and I could not discover them; but I rather think there were none, and that those were the males: but in others I have observed long recurvous tails, longer than their whole bodies; and these I take to be the females. And in the *oak-apples* themselves I have seen the *aurelia*, some with, some without tails. And I must confess, it was not without admiration as well as pleasure, that I have seen with what exact neatness and artifice the tail hath been wrapt about the *aurelia*, whereby it is secured from either annoying the insect, or being hurt itself.

(*cc*) See before, note (*z*).

(*ff*) As in the preceding note.

(*gg*) Of the rough or hairy excrescences, those on the *briar*, or *dog-rose*, are a good instance. Plate K, *fig.* 6, 7. These *spongiolæ villosæ*, as Mr. Ray, *gallæ ramosæ*, as Dr. *Malpighi* calls them, are thus accounted for by the latter: *Ex copiosis relictis ovis ita turbatur affluens [Rubi] succus, ut strumosa fiant complura tubercula simul confusè congesta, quæ utriculorum seriebus, & fibrarum implicatione contexta, ramosas propagines germinant, ita ut minima quasi sylva appareat. Quælibet propago ramos hinc inde villosos edit. Hinc inde pili pariter erumpunt, &c.*—"From the number of eggs that the insect leaves in the plant, its juices are so disturbed that little strumous swellings are found close to each other about the place; which, from the fibres being thus contorted between these little bags, produce a number of minute and bushy twigs like a small forest. Each twig has its rough branches, beset with hairs breaking out on every side."

These balls are a safe repository to the insect all the winter in its vermicular state. For the eggs laid up and hatched the summer before, do not come to mature insects until the spring following, as Mr. Ray rightly observes in *Cat. Cantab.*

with peculiar and exactly made parts for this service, to bore and pierce the vegetable, and to reach and inject their eggs and juice into the tender parts thereof.

As to the *insects* themselves, *fig. 8*, they are manifestly *ichneumon-flies*, having four wings, their *alvus* thick and large towards the tail, and tapering up till it is small and slender at its setting on to the *thorax*. But the *alvi* or bellies are not alike in all, though coloured alike. In some they are as is now described, and longer, without *terebra* or tails; in some shorter with tails; and in some yet shorter and thick, like the belly of the *ant*, or the heart of animals, as in those before, *note (z)*. But for a farther description of them, I shall refer to Mr. Ray, *Cat. Plant. circa Cantab.* under *Rosa sylvest.*

(*hh*) It being an instance somewhat out of the way, I shall pitch upon it for an example here, *viz.* the *gouty swellings* in the body, and the branches of the *blackberry-bush*; of which *Malpighi* hath given us two good cuts in *tab. 17. fig. 62*. The cause of these is manifestly from the eggs of insects laid in (whilst the shoot is young and tender) as far as the pith, and in some places not so deep; which, for the reasons beforementioned, makes the young shoots tumify and grow knotty and gouty.

The insect that comes from hence is of the former tribe, a small, shining black *ichneumon-fly*, about a tenth of an inch long; with jointed, red, capillary horns, four long wings reaching beyond the body, a large *thorax*, red legs, and a short heart-like belly. They hop like fleas. The males are less than the females; are very venereous, endeavouring a *coit* in the very box in which they are hatched; getting up on the females, and tickling and thumping them with their breeches and horns to excite them to venery.

K



1. 2. The Gall-nut bred upon Oak leaves. 3. The same laid open shewing the nest of the insect. 4. A squamous or scaly Gall-nut growing on the Oak 5. The fly produced from the round gall-nut. 6. The hairy excrescence growing on the Dog-rose. 7. The same laid open. 8. The fly bred in it. 9. The terebra or borer with which the fly pierces the leaves to inject its eggs.

The Conclusion.

AND now these things being seriously considered, what less can be concluded, than that there is manifest design and forecast in this case, and that there must needs be some wise Artist, some careful prudent Conservator, that from the very beginning of the existence of this species of animals, hath with great dexterity and forecast provided for its preservation and good? For what else could contrive and make such a set of curious parts, exactly fitted up for that special purpose, and withal implant in the body such peculiar impregnations, as should have such a strange and unaccountable power on a quite different rank of creatures? And lastly, what should make the insect aware of this its strange faculty and power, and teach it so cunningly and dextrously to employ it for its own service and good?

B O O K IX.

Of Reptiles, and the Inhabitants of the
Waters.

C H A P. I.

Of Reptiles.

HAVING dispatched the insect tribe, there is but one *genus* of the land-animals remaining to be surveyed; and that is, that of *reptiles* (*a*); which I shall dispatch in a little compass, by reason
I have

(*a*) Notwithstanding I have before, in *book iv. chap. 12. note (p)*, taken notice of the *earth-worm*; yet it being a good example of the Creator's wise and curious workmanship, in even this meanest branch of the creation, I shall superadd a few farther remarks from Drs. *Willis* and *Tyson*. Saith *Willis*, *Lumbricus terrestris, licet vile & contemptibile habetur, organa vitalia, necnon & alia viscera, & membra divino artificio admirabiliter fabricata sortitur: totius corporis compages muscutorum annularium catena est, quorum fibræ orbiculares contractæ quemque anulum, prius amplum, & dilatatum, angustiore & longiore reddunt.*—"The earth-worm, though it appears a vile and contemptible insect, has its vital organs and other viscera admirably framed, by a skill which can be nothing less than divine. The whole body is a chain of annular muscles, whose orbicular fibres, when contracted, render each

I have somewhat amply treated of others, and many of the things may be applied here. But there are some things in which this tribe is somewhat singular, which I shall therefore take notice of briefly in this place. One is their motion, which

I have

each ring, which was before wide and dilated, narrower and longer.”—[This muscle in earth-worms I find is spiral, as in a good measure is their motion likewise; so that by this means they can (like the worm of an augre) the better bore their passage into the earth. Their reptile motion also may be explained by a wire wound on a cylinder, which, when slipped off and one end extended and held fast, will bring the other nearer it. So the earth-worm, having shot out or extended its body, (which is with a wreathing,) it takes hold by those small feet it hath, and so contracts the hinder part of its body. Thus the curious and learned Dr. Tyson, Philos. Transf. No. 147.] *Nam proinde cum portio corporis superior elongata, & exporrecta, ad spatium alterius extenditur, ibidemque plano affigitur, ad ipsum quasi ad centrum portio corporis inferior relaxata, & abbreviata facile pertrahitur. Pedunculi serie quadruplici, per totam longitudinem lumbrici disponuntur; his quasi totidem uncis, partem modò hanc, modò istam, plano affigit, dum alteram exporrigit, aut post se ducit. Supra oris hiatus, proboscide, quâ terram perforat & elevat, donatur.*—“For when the upper part of its body is elongated and stretched out, so as to occupy a much larger space, it fixes itself to the surface by the upper part, and the inferior portion of the animal being relaxed and shortened, it is easily drawn after. It has a quadruple row of feet all along the body. By these, as by so many hooks, it fixes sometimes one part and sometimes another of its body to the ground, and stretches out or draws after it the rest. Above the orifice of the mouth, it has a proboscis or trunk with which it perforates the ground.”—And then he goes on with the other parts that fall under view, the brain, the gullet, the heart, the spermatie vessels, the stomachs and intestines, the foramina on the top of the back, adjoining to each ring, supplying the place of lungs, and other parts. *Willis de Anim. Brut. p. 1. c. 3.*

I have in another place (*b*) taken notice of to be not less curious, than it is different from that of other animals, whether we consider the manner of it as vermicular or sinuous (*c*), or like that of the snail (*d*), or the caterpillar (*e*), or the multipe-

dous,

(*b*) In *book iv. chap. 8.*

(*c*) There is a great deal of geometrical neatness and nicety in the sinuous motion of snakes, and other serpents. For the assisting in which action, the annular scales under their body are very remarkable, lying cross the belly, contrary to what those in the back and the rest of the body do: also, as the edges of the foremost scales lie over the edges of their following scales, from head to tail; so those edges run out a little beyond, or over their following scales; so as that when each scale is drawn back, or set a little upright by its muscle, the outer edge thereof (or foot it may be called) is raised also a little from the body, to lay hold on the earth, and so promote and facilitate the serpent's motion. This is what may be easily seen in the flough, or belly of the serpent-kind. But there is another admirable piece of mechanism, that my antipathy to those animals hath prevented my prying into; and that is, that every scale hath a distinct muscle, one end of which is tacked to the middle of its scale; the other, to the upper edge of its following scale. This Dr. *Tyson* found in the *rattle-snake*, and I doubt not is in the whole tribe.

(*d*) The wise Author of Nature, having denied feet and claws to enable snails to creep and climb, hath made them amends in a way more commodious for their state of life, by the broad skin along each side of the belly, and the undulating motion observable there. By this latter it is they creep; by the former, assisted with the glutinous slime emitted from the snail's body, they adhere firmly and securely to all kinds of superficies, partly by the tenacity of their slime, and partly by the pressure of the atmosphere. Concerning this part, (which he calls the *snail's feet*,) and their undulation, see Dr. *Lister's Exercit. Anat.* 1, sect. 1 and 37.

(*e*) The motive parts, and motion of caterpillars, are useful,

dous (*f*), or any other way ; or the parts ministring to it, particularly the spine (*g*), and the muscles co-operating with the spine, in such as have bone,

not only to their progression and conveyance from place to place ; but also to their more certain, easy, and commodious gathering of food. For having feet before and behind, they are not only enabled to go by a kind of steps made by their fore and hind parts ; but also to climb up vegetables, and to reach from their boughs and stalks for food at a distance ; for which services, their feet are very nicely made both before and behind. Behind, they have broad palms for sticking to, and these beset almost round with small sharp nails, to hold and grasp what they are upon ; before, their feet are sharp and hooked, to draw leaves, &c. to them, and to hold the forepart of the body, whilst the hinder parts are brought up thereto. But nothing is more remarkable in these reptiles, than that these parts and motion are only temporary, and incomparably adapted only to their present *nympha* state ; whereas in their *aurelia* state, they have neither feet nor motion, only a little in their hinder parts : and in their *mature* state, they have the parts and motion of a flying insect, made for flight.

(*f*) It is a wonderful pretty mechanism, observable in the going of *multipedes*, as the *juli*, *scolopendræ*, &c. that on each side the body, every leg hath its motion, one very regularly following the other from one end of the body to the other, in a way not easy to be described in words ; so that their legs in going, make a kind of undulation, and give the body a swifter progression than one would imagine it should have, where so many feet are to take so many short steps.

(*g*) *Vertebrarum apophyses breviores sunt, præcipue juxta caput, cujus propterea flexus in aversum, & latera, facilis viperis est : secus leonibus, &c.—Incumbit his ossibus ingens musculorum minorum præsidium, tum spinas tendinum exilium magno apparatu diducentium, tum vertebrae potissimum in diversa flectentium, atque erigentium. Adeoque illam corporis miram agilitatem, non tantum (ut Aristot.)*
ὅτι εύκαμπτεῖς καὶ χονδρώδεις ἢ σπόνδυλοι quoniam faciles ad flexum, &
cartila-

bone, and the annular, and other muscles, in such as have none, all incomparably made for those curious, and, I may say, geometrical windings and turnings, undulations, and all the various motions to be met with in the reptile kind.

Another thing that will deserve our notice, is, the poison (*b*) that many of this tribe are stocked with.

cartilagineas produxit vertebrae, sed quia etiam multiplicia motus localis instrumenta musculos fabricavit provida rerum parens Natura; consecuta fuit.—"The knots of the vertebræ are shorter towards the head, and hence the viper can easily bend itself both backwards and sideways. It is not so in the vertebræ of the lion. In that animal those bones are strongly guarded by a great number of small muscles, which serve both to draw asunder the ends of the small tendons, and more particularly to bend the vertebræ different ways, and to stiffen them. And thus that part of the body possesses such wonderful agility, not only because the vertebræ are made flexible and cartilaginous, but because Nature in her bounty has formed those muscles as the numerous and various instruments of local motion."—*Blas. Anat. Anim. p. 1. c. 39. de Viperâ à Veslingio.*

That which is most remarkable in the vertebræ [of the rattle-snake, besides the other curious articulations] is, that the round ball in the lower part of the upper vertebra, enters a socket of the upper part of the lower vertebra, like as the head of the os femoris doth the acetabulum of the os ischii; by which contrivance, as also the articulation with one another, they have that free motion of winding their bodies any way. Dr. Tyson's *Anat. of the Rattle-snake* in *Philos. Transf.* No. 144. What is here observed of the vertebræ of this snake, is common to this whole genus of reptiles.

(*b*) My ingenious and learned friend, Dr. Mead, examined with his microscope, the texture of a viper's poison, and found therein at first only a parcel of small salts nimbly floating in the liquor; but in a short time the appearance was changed, and these saline particles were shot out into crystals, of an incredible tenuity and sharpness,

with. Which I the rather mention, because some make it an objection against the Divine superintendence and providence, as being a thing so far from useful, (they think,) that it is rather mischievous and destructive of God's creatures. But the answer is easy, *viz.* That as to man, those creatures are not without their great uses, particularly in the cure of (*i*) some of the most stubborn diseases;

sharpness, with something like knots here and there, from which they seemed to proceed; so that the whole texture did in a manner represent a spider's web, though infinitely finer. Mead of Poisons, p. 9.

As to the nature and operation of this *poison*, see the same ingenious author's hypothesis, in his following pages.

This *poison* of the *viper* lieth in a bag in the gums, at the upper end of the teeth. It is separated from the blood by a *conglomerated gland*, lying in the anterior lateral part of the *os incisivitis*, just behind the orbit of the eye: from which gland lieth a duct, that conveys the poison to the bags at the teeth.

The teeth are tubulated, for the conveyance or emission of the poison into the wound the teeth make; but their hollowness doth not reach to the *apex*, or top of the tooth (that being solid and sharp, the better to pierce); but it ends in a long slit below the point out of which the poison is emitted. These perforations of the teeth, *Galen* saith, the mountebanks used to stop with some kind of paste, before they suffered the vipers to bite them before their spectators. Cuts of these parts, &c. may be seen in the last cited book of Dr. *Mead*. Also Dr. *Tyson's Anat. of the Rattle-snake*, in *Phil. Transf.* No. 144.

(*i*) That vipers have their great uses in physic, is manifest from their bearing a great share in some of our best antidotes, such as *theriaca andromachi*, and others; also in the cure of the *elephantiasis*, and other the like stubborn maladies, for which I shall refer to the medical writers. But there is so singular a case in the curious collection of Dr. *Ol. Worm*, related from

diseases; however, if they were not, there would be no injustice for God to make a set of such
noxious

Kircher, that I shall entertain the reader with it. Near the village of *Sassa*, about eight miles from the city *Bracciano* in *Italy*, saith he, *Specus seu caverna (vulgò la Grotta delli Serpi) duorum hominum capax, fistulosis quibusdam foraminibus in formam cribri perforata cernitur, ex quibus ingens quædam, principio veris, diversicolorum serpentum, nullâ tamen, ut dicitur, singulari veneni qualitate imbutorum progenies quotannis pullulare solet. In hæc speluncâ elephantiacos, leprosos, paralyticos, arthriticos, podagricos, &c. nudos exponere solent, qui mox halituum subterraneorum calore in sudorem resoluti, serpentum propullulantium, totum corpus infirmi implicantium, suctu linctuque ita omni vitioso virulentoque humore privare dicuntur, ut repetito hoc per aliquod tempus medicamento, tandem perfectæ sanitati restituantur.*—"There is a hole or cavern called the Grotto of Serpents, which is large enough to contain two men, and it is all perforated with small holes like a sieve. From these holes, in the beginning of spring, there issues a prodigious number of small different coloured serpents, of which every year produces a new brood, but which seem to have no poisonous quality. It is customary to lay down in the cavern, naked, such persons as are afflicted with white scurvy, leprosy, palsy, arthritis, gout, &c. and their bodies being subject to a copious sweat from the heat of the subterraneous vapours, the young serpents fasten themselves on every part, and extract, as is said, by their sucking, every diseased or vitiated humour; so that after some repetitions of this mode of cure, the diseased persons are restored to perfect health."—This cave *Kircher* visited himself, found it warm, and every way agreeable to the description he had of it; he saw their holes, heard a murmuring hissing noise in them; but although he missed seeing the serpents, (it being not the season of their creeping out,) yet he saw great numbers of their exuvia, or sloughs, and an elm growing hard by laden with them.

The discovery of this cave, was by the cure of a leper going from *Rome* to some baths near this place; who losing his way,

noxious creatures, as rods and scourges, to execute the divine chastisements upon ungrateful and sinful men. As to the animals themselves, their poison is, no doubt, of some great and especial use to themselves, serving to the more easy conquest, and sure capture of their prey, which might otherwise be too resty and strong, and if once escaped, would hardly be again recovered, by reason of their swifter motion, and the help of their legs; besides all which, this their poison may be probably of very great use to the digestion of their food.

And as to the innocuous part of the reptile-kind, they as well deserve our notice for their harmlessness, as the others did for their poison. For as those are endowed with poison, because they are predaceous; so these need it not, because their food is near at hand, and may be obtained without strife and contest, the next earth (*k*) affording food
to

and being benighted, happened upon this cave; and finding it very warm, pulled off his clothes, and being weary and sleepy, had the good fortune not to feel the serpents about him till they had wrought his cure. Vide *Museum Worm.* l. 3. c. 9.

The before-commended Dr. *Mead*, thinks our physicians deal too cautiously and sparingly, in their prescribing only small quantities of the viper's flesh, &c. in the *elephantiasis*, and stubborn *leprosy*; but he recommendeth rather the jelly or broth of vipers; or, as the ancient manner was, to boil vipers, and eat them like fish; or at least to drink wine, in which they have been long infused. Vide *Mead, ubi supra*, p. 34.

(*k*) That *earth-worms* live upon earth, is manifest from the little curled heaps of their dung ejected out of their holes. But in *Philos. Transf.* No. 291, I have said, it is in all probability
earth

to such as can terebrate, and make way into it by their vermicular faculty; and the next vegetable being food to others that can climb and reach (*l*), or but crawl to it.

earth made of rotted roots and plants, and such like nutritive things, not pure earth. And there is farther reason for it, because worms will drag the leaves of trees into their holes.

(*l*) *Snails* might be in danger of wanting food, if they were to live only upon such tender plants as are near the ground, within their reach only; to impower them therefore to extend their pursuits farther, they are enabled, by the means mentioned in *note* (*d*), to stick unto, and creep up walls and vegetables at their pleasure.

CHAP. II.

Of the Inhabitants of the Waters.

I Have now gone through that part of the animal world, which I propos'd to survey, the animals inhabiting the land.

As to the other part of the terraqueous globe, the waters, and the inhabitants thereof, not having time to finish what I have begun on that large subject, I shall be forced to quit it for the present, although we have there as ample and glorious a scene of the infinite Creator's power and art, as hath been already set forth on the dry land. For the waters themselves are an admirable work of God (*a*), and
of

(*a*) Besides their absolute necessity, and great use to the world, there are several topics, from whence the waters may be demonstrated to be God's work; as, the forming so vast a part of our globe; the placing it commodiously therein, and giving it bounds; the methods of keeping it sweet and clean, by its saltness*, by the tides, and agitations by the winds; the
making

* The saltness of the sea proceeds from the recrements of animal and vegetable bodies; such as phosphoric, ammoniacal, marine salt, and other substances: these are washed from the earth by rains and carried down our rivers into the sea. They seem all here to decompose each other, except the marine salt, which has therefore from the beginning of the habitable world been perpetually accumulating. The rock salt that is found in
great

of infinite use (*b*) to that part of the globe already surveyed; and the prodigious variety (*c*), and multitudes of curious and wonderful things observable in its inhabitants of all sorts, are an inexhaustible

making the waters useful to the vegetation of plants, and for food to animals, by the noble methods of sweetening them; and many other things besides, which are insisted on in that part of my survey.

(*b*) *Pliny* having named divers *mirabilia aquarum*, to shew their power; then proceeds to their uses, viz. *Eadem cadentes omnium terrâ nascentium causa fiunt, prorsus mirabili naturâ, si quis velit reputare, ut fruges gignantur, arbores fruticesque vivant, in cælum migrare aquas, animamque etiam herbis vitalem inde deferre: justâ confessione, omnes terræ quoque vires aquarum beneficii. Quapropter ante omnia ipsarum potentie exempla ponemus: Cunctas enim quis mortalium enumerare queat?*—“These showers are the cause of all that the earth produces; and how astonishingly various is that fecundity if we consider the growth of grain and fruits, of trees and shrubs; that the water raised by evaporation to the heavens, seems thence to draw that vivifying principle which it imparts to every herb and plant: we must, in short, confess that the earth derives all its powers from the waters. Therefore let us proceed to enumerate a few examples of the virtues and properties of those waters; for what mortal can recount them all?”—And then he goes on with an enumeration of some waters famed for being medicinal, or some other unusual quality.—*Plin. l. 31. c. 1 & 2.*

(*c*) *Pliny* reckons 176 kinds in the waters, whose names may be met with in his *l. 32. c. 11.* but he is short in his account.

great masses in the bowels of the earth, seems to have been produced by the evaporation of sea water, caused by intestine fires in the early periods of the world. As sea shells are found at great depths in the earth, wherever these have been discovered, we are certain that the sea water must likewise have had access: but I know not whether it has been remarked that there are any
strata,

haustible scene of the Creator's wisdom and power. The vast bulk of some (*d*), and prodigious minuteness of others (*e*), together with the incomparable contrivance and structure of the bodies (*f*) of all; the provisions and supplies of food afforded to

(*d*) *Pliny*, l. 9. c. 3. saith, That in the *Indian* sea there are *balena quaternum jugerum* (i. e. 960 feet) *pristes* 200 cubitorum (i. e. 300 feet). And l. 32. c. 1. he mentions *whales* 600 feet long, and 360 broad, that came into a river of *Arabia*. If the reader hath a mind, he may see his reason why the largest animals are bred in the sea, l. 9. c. 2.

(*e*) As the largest, so the most minute animals are bred in the waters, as those in pepper-water; and such as make the green scum on the waters, or make them seem as if green, and many others. See *book* iv. *chap.* 11. *note* (*n*), (*o*).

(*f*) It might be here shewn, that the bodies of all the several inhabitants of the waters, are the best contrived and suited to that place and business in the waters which is proper for them; that particularly their bodies are cloathed and guarded, in the best manner, with scales, or shells, &c. suitable to the place they are to reside in, the dangers they may there be exposed unto, and the motion and business they are there to perform: that the centre of gravity (of great consideration in that fluid element) is always placed in the fittest part of the body: that the shape of their bodies (especially the more swift) is the most commodious for making way through the waters, and most agreeable to geometrical rules; and many other matters besides would deserve a place here, were they not too long for notes, and that I shall anticipate what shall be more proper for another place, and more accurately treated of there.

strata of sea shells in the neighbourhood of salt mines. The sea water around the shores of Britain contains about one twenty-eighth or one thirtieth part of sea salt, and about one eightieth of magnesian salt.

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to such an innumerable company of eaters *, and that in an element, unlikely, one would think, to afford any great store of supplies (g); the business of respiration performed in a way so different from, but equivalent to what is in land animals (h); the adjustment

(g) See before book iv. chap. 11.

(h) Galen was aware of the respiration of fishes by their *branchiæ*. For having said, that fishes have no occasion for a voice, neither respire through the mouth as land animals do, he saith, *Sed earum, quas branchias nuncupamus, constructio, ipsis vice pulmonis est. Cùm enim crebris ac tenuibus foraminibus sint branchiæ hæ interceptæ, aëri quidem & vapor perviis, subtilioribus tamen quàm pro mole aquæ; hanc quidem extra repellunt, illa autem promptè intromittunt.*—"But the gills from their construction serve instead of lungs. For being perforated with a great number of very minute holes which are pervious to air and vapour, but too small to admit the particles of water, they exclude the latter entirely,

* Fishes are the most voracious animals in nature. Many Species prey indiscriminately on every thing digestible that comes in their way, and devour not only other species of fishes, but even their own. As a counterbalance to this voracity, they are amazingly prolific. Some bring forth their young alive; others produce only eggs. The viviparous blenny brings forth 200 or 300 live fishes at a time. Those which produce eggs are all much more prolific, and seem to proportion their stock to the danger of consumption. Lewenhoeck affirms that the cod spawns above nine millions in a season. The flounder produces above one million, and the mackarel above 500,000. Scarce one in a hundred of these eggs, however, comes to maturity: but two wise purposes are answered by this amazing increase; it preserves the species in the midst of numberless enemies, and serves to furnish the rest with a sustenance adapted to their nature. *Encycl. Britan. Art. Ichthyology.* EDITOR.

adjustment of the organs of vision (*i*) to that element in which the animal liveth; the poise (*k*), the support,

tirely, while they give free admission to the former.”—*Galen de Uf. Part.* l. 6. c. 9. So also *Pliny* held, that fishes respired by their gills; but he saith *Aristotle* was of a different opinion. *Pliny*, l. 9. c. 7. And so *Aristotle* seems to be in his *History of Animals*, l. 8. c. 2. and in other places. And I may add our famous *Dr. Needham*. See his *De Form. Fetus*, chap. 6. and *Answer to Severinus* *.

(*i*) A protuberant eye would have been inconvenient for fishes, by hindering their motion in so dense a medium as water is; or else their brushing through so thick a medium would have been apt to wear, and prejudice their eyes; therefore their cornea is flat. To make amends for which, as also for the refraction of water, different from that of the air, the wise Contriver of the eye hath made the crystalline spherical in fishes, which in animals, living in the air, is lenticular, and more flat †.

(*k*) As I have shewed before, that the bodies of birds are nicely poised to swim in the air; so are those of fishes for the water,

* The motion of the gills of fishes performed at regular intervals seems to be analogous to our breathings, and it is probably the operation by which they separate the air from the water. The fish first takes in a quantity of water by the mouth, which is driven to the gills; these close, and keep the water which is taken in from returning by the mouth, while the bony covering of the gills prevents it from going through them, till the animal has drawn the proper quantity of air from it: then the bony cover opens and gives it a free passage; by which means also the gills are again opened, and admit a fresh quantity of water. If the fish is prevented from the free play of its gills, it soon falls into convulsions and dies.

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† From the structure of the eyes of fishes it has been supposed that the sense of seeing is very imperfect in this class of animals; but

support (*l*), the motion of the body (*m*), forwards with great swiftness *, and upwards and downwards with great readiness and agility, and all without feet and hands, and ten thousand things besides ;
all

water, every part of the body being duly balanced, and the centre of gravity (as I said in *note* (*f*)), accurately fixed. And to prevent vacillation, some of the fins serve, particularly those of the belly ; as *Borelli* proved, by cutting off the belly-fins, which caused the fish to reel to the right and left hand, and rendered it unable to stand steadily in an upright posture.

(*l*) To enable the fish to abide at the top, or bottom, or any other part of the waters, the air-bladder is given to most fishes, which, as it is more full or empty, makes the body more or less buoyant.

(*m*) The *tail* is the grand instrument of the motion of the body : not the fins, as some imagine. For which reason, fishes are more musculous and strong in that part, than in all the rest of their body, according as it is in the motive parts of all animals, in the pectoral muscles of birds, the thighs of man, &c.

If the reader hath a mind to see the admirable method, how fishes row themselves by their tail, and other curiosities relating to their swimming ; I shall refer him to *Borelli de Mot. Animal.* Part 1. chap. 23. particularly to *Prop.* 213.

but the circumstance of their darting with velocity from a great distance to small crevices of rocks and stones, or trunks of trees, and other places of shelter, and their springing out of the water to a considerable height to catch flies, and that in an evening when it is so dark that the insects which attract them, escape our sight altogether, affords convincing proof that they must possess the sense of seeing in very great perfection. EDITOR.

* The swiftness even of moderate sized fishes is so great, that they overtake with ease a ship at full sail, and play round it as if it were motionless in the water. EDITOR.

all these things, I say, do lay before us so various, so glorious, and withal so inexhaustible a scene of the Divine power, wisdom, and goodness, that it would be in vain to engage myself in so large a province, without allotting as much time and pains to it, as the preceding survey hath cost me. Passing by therefore that part of our globe, I shall only say somewhat very briefly concerning the *insensitive* creatures, particularly those of the *vegetable kingdom*, and so conclude this survey.

B O O K X.

Of Vegetables.

THE vegetable kingdom, although an inferior branch of the creation, exhibits to us such an ample scene of the Creator's contrivance, curiosity, and art, that I much rather choose to shew what might be said, than engage too far in particulars. I might insist upon the great variety there is, both of trees and plants provided for all ages, and for every use and occasion of the world (*a*); some for building, for tools and utensils of every kind; some hard, some soft; some tough and strong, some brittle; some long and tall, some short and low; some thick and large, some small and slender; some for physic (*b*), some for food, some for pleasure;

(*a*) The fifth book of *Theophrastus's History of Plants* may be here consulted; where he gives ample instances of the various constitutions and uses of trees, in various works, &c. See also before, book iv. chap. 13. note (*a*).

(*b*) *Invisis quoque herbis inseruit [Natura] remedia: quippe cum medicinas dederit etiam aculeatis—in quibus ipsis providentiam Naturæ satis admirari amplectique non est. Inde excogitavit aliquas aspectu hispidas, tactu truces, ut tantum non vocem ipsius fingentis illas,*

ture; yea, the most abject (c) shrubs, and the very bushes and brambles themselves, the husbandman can testify the use of.

I might

illas, rationemque reddentis exaudire videamur, ne se depascat avida quadrupes, ne procaces manus rapiant, ne neglecta vestigia obterant, ne insidens ales infringat: his muniendo aculeis, telisque armando, remediis ut tuta ac salva sint. Ita hoc quoque quod in iis odimus, hominum causâ excogitatum.—“Nature hath given medicinal qualities to plants that are odious and disgusting to the senses, and even to such as are offensive by their prickles; and in this we cannot sufficiently admire her wise and provident œconomy. For some she has made so unpleasant to the sight, and offensive to the touch, that we seem almost to hear her voice forbidding the beasts of the field to brouze upon them, the idle hand to pluck them, the careless footstep to encounter them, or the fowls of the air to perch upon them; thus guarding them, as if by their own arms, and preserving them safe for their medicinal uses. And thus it is on man’s own account that they are endowed with those very qualities for which he hates and shuns them.”—*Plin. Nat. Hist. l. 22. c. 6.*

Are some of the species of Nature noxious? They are also useful. Doth a nettle sting? It is to secure so good a medicine from the rapes of children and cattle. Doth the bramble cumber a garden? It makes the better hedge; where if it chanceth to prick the owner, it will tear the thief. Grew. Cosmolog. lib. 3. cap. 2. sect. 47.

(c) That the most abject vegetables, &c. have their use, and are beneficial to the world, may in some measure appear from the use the northern people put rotten wood, &c. unto. *Satis ingeniosum modum habent populi septentrionales in memoribus nocturno tempore pertranseuntes, imo & diurno, quando in remotioribus aquilonis partibus ante, & post solstitium hyemale continuæ noctes habentur. Quique his remediis indigent, cortices quercinos inquirunt putres, easque collocant certo interslitio itineris institui, ut eorum splendore, quod voluerint, perficiant iter. Nec solum hoc præstat cortex, sed & truncus putrefactus, ac fungus ipse agaricus appellatus, &c.*—“The people of the northern countries shew considerable ingenuity when travelling

I might also survey here the curious anatomy and structure of their bodies (*d*), and shew the admirable

velling through the forests in the night, or even in the day-time (for in those arctic regions, both before and after the winter solstice, they have continual night). They search out the rotten bark of oak, and place portions of it at certain intervals along the way where their journey lies, that they may see to travel by their light. It is not the bark alone that is endowed with this quality of shining in the dark, but the trunk itself and those *fungi* or *agarics* that grow upon it."—*Ol. Mag. Hist.* l. 2. c. 16.

To this we may add *thistles* in making glass, whose ashes Dr. Merret saith, are the best, viz. the ashes of the *common-way thistle*, though all *thistles* serve to this purpose. Next to *thistles* are *hop-strings*, cut after the flowers are gathered. Plants that are thorny and prickly seem to afford the best and most salt. Merret's *Observations on Anton. Ner.* p. 265.

*Quid majora sequar? salices, humilesque genistæ,
Aut illæ pecori frondem, aut pastoribus umbram
Sufficiunt, sepemque satis, & pabula melli.*

VIRG. Georg. lib. 2. ver. 434.

"Even humble broom and oziers have their use,
And shade for sheep, and food for flocks produce;
Hedges for corn, and honey for the bees."——

DRYDEN'S *Virg.*

(*d*) Dr. Beal (who was very curious, and tried many experiments upon vegetables) gives some good reasons to imagine, that there is a direct communication between the parts of the tree and the fruit, so that the same fibres which constitute the root, trunk, and boughs, are extended into the very fruit. And in old *horn-beams* I have observed something very like this; in many of which there are divers great and small ribs (almost like ivy, only united to the body) running from the root up along the outside of the body, and terminating in one

admirable provision made for the conveyance of the lymphatic and essential juices, for communicating the air, as necessary to vegetable as animal life (*e*): I might also speak of even the very covering

single or a few boughs; which bough or boughs spread again into branches, leaves, and fruit. See what Dr. *Beal* hath in *Lowth. Abridg.* vol. 2. p. 710.

But as to the particular canals, and other parts relating to the anatomy of vegetables, it is too long a subject for this place, and therefore I shall refer to *Sign. Malpighi's* and Dr. *Grew's* labours in this kind.

(*e*) *Tanta est respirationis necessitas & usus, ut Natura in singulis viventium ordinibus varia, sed analogia, paraverit instrumenta, quæ pulmones vocamus.*—"Such is the use and necessity for respiration, that Nature has provided in all the species of living creatures various, but at the same time analogous organs for that purpose, which we call lungs."—[And so he goes on with observing the *apparatus* made in the various genera of animals, and then saith:] *In plantis verò, quæ infimum animalium attingunt ordinem, tantam trachearum copiam & productionem extare par est, ut his minime vegetantium partes præter corticem irrigentur.*—*Plantæ igitur (ut conjectari fas est) cum sint vivencia, visceribus infixæ terræ, ab hac, seu potius ab aquâ & aëre, commixtis & percolatis à terrâ, respirationis suæ materiam recipiunt, ipsarumque trachææ ab halitu terræ, extremas radices subingresso, replentur.*—"In plants, which are the lowest species of animals, there is such a number of trachææ or air-vessels that the minute parts of vegetables (except the bark) seem to receive their nutriment by them. Plants then, we may conjecture, as they are living substances attached by their viscera to the earth, seem to receive from it, or rather from the water and air mixed and strained by the earth, the respirable matter, and are filled by the vapour from the earth entering and penetrating the roots."—*Malpig. Op. Anat. Plant.* p. 15.

These *trachææ* or *air-vessels* are visible and appear very pretty in the leaf of *scabious*, or the vine, by pulling asunder some of its

ing they are provided with, because it is a curious work in reality, although less so in appearance: And much more therefore might I survey the neat variety and texture of their leaves (*f*), the
 admirable

its principle ribs or great fibres; between which may be seen the spiral *air-vessels* (like threads of cobweb) a little uncoiled: See Plate N, *fig.* 1. A figure whereof Dr. *Grew* hath given us in his *Anat. Plant.* tab. 51, 52.

As to the curious coiling, and other things relating to the structure of those *air-vessels*, I refer to *Malpig.* p. 14. and Dr. *Grew*, *ib.* l. 3. c. 3. sect. 16, &c. and l. 4. c. 4. sect. 19. of Mr. *Ray*, from them succinctly, *Hist. Plant.* l. 1. c. 4.

(*f*) Concerning the *leaves*, I shall note only two or three things. 1. As to the *fibres of the leaf*, they stand not in the *stalk*, in an even line, but always in an angular or circular posture, and their vascular fibres or threads are 3, 5, or 7. The reason of their position thus, is for the more erect growth and greater strength of the leaf, as also for the security of its sap. Of all which see Dr. *Grew*, l. 1. c. 4. sect. 8. &c. and l. 4. par. 1. c. 3. also tab. 4. *fig.* 2 to 11. Another, observable in the fibres of the leaf, is their orderly position, so as to take in an eighth part of a circle, as in *mallows*; in some a tenth, but in most a twelfth, as in *holy-oak*; or a sixth, as in *syringa*. *Id.* *ib.* tab. 46, 47.

2. The art in *folding up the leaves* before their eruption out of their gems, &c. is incomparable, both for its elegancy and security, viz. In taking up (so as their forms will bear) the least room; and in being so conveniently couched as to be capable of receiving protection from other parts, or of giving it to one another; e. g. First, there is the *bow-lap*, where the leaves are all laid somewhat convexly one over another, but not plaited; but where the leaves are not so thick set, as to stand in the *bow-lap*, there we have the *plicature* or the *flat-lap*, as in *rose-trees*, &c. And so that curious observer goes on shewing the various foldings, to which he gives the names of the *duplication*, *multiplication*, the *fore-rowl*, *back-*
 A A 2 rowl,

admirable finery, gaiety, and fragrancy of their flowers (g). I might also inquire into the wonderful generation

rowl, and *tre-rowl*, or *treble-rowl*. Grew, *ib.* l. 1. c. 4. sect. 14. &c. To these he adds some others, l. 4. p. 1. c. 1. sect. 9. Consult also *Malpig. de Gemmis*, p. 22, &c.

To these curious foldings we may add another noble guard by the interposition of *films*, &c. of which Dr. Grew saith there are about six ways, *viz.* *leaves*, *surfoils*, *interfoils*, *stalks*, *hoods*, and *mantlings*. Grew, *ib.* and *tab.* 41, 42. *Malpig. ibid.*

(g) In the flower may be considered the *empalement*, as Dr. Grew; the *calix* or *perianthium*, as Mr. Ray and others call it, designed to be a security and bands to the other parts of the flower. *Floris velut basis & fulcimentum est.*—"It is as it were the base and support of the flower."—Ray *Hist.* l. 1. c. 10. Flowers, whose *petala* are strong (as tulips) have no *calix*. *Carnations*, whose *petala* are long and slender, have an empalement of one piece: and others, such as the *knap-weeds*, have it consisting of several pieces, and in divers rounds, and all with a counterchangeable respect to each other, for the greater strength and security of themselves and the *petala*, &c. they include.

The next is the *foliation*, as Dr. Grew, the *petala* or *folia*, as Mr. Ray and others. In these, not only the admirable beauty and luxuriant colours are observable, but also their curious *foldings* in the *calix* before their expansion. Of which Dr. Grew hath these varieties, *viz.* the *close-couch*, as in *roses*; the *conclave-couch*, as in *blattaria flore albo*; the *single-plait*, as in *pease-blossoms*; the *double-plait*, as in *blue-bottles*, &c.; the *couch* and *plait* together, as in *marigolds*, &c.; the *rowl*, as in *ladies-bower*; the *spire*, as in *mallows*; and lastly, the *plait* and *spire* together, as in *convolvulus daronici folio*. Lib. 1. cap. 5. sect. 6. and *tab.* 54.

As to the *stamina* with their *apices*, and the *stylus*, (called the *attire* by Dr. Grew,) they are admirable, whether we consider their colours or make, especially their use, if it be as Dr. Grew, Mr. Ray, and others imagine, namely, as a *male sperm*, to impregnate

generation * and make of the seed (*b*), and the great usefulness of their fruit: I might shew that the rudiments and lineaments of the parent-vegetable, though never so large and spacious, is locked up in the little compass of their fruit or seed, (see Pl. N, fig. 3, 4.) though some of these seeds are scarce visible to

pregnate and fructify the seed †: which opinion is corroborated by the ingenious observations of Mr. Samuel Morland, in *Philos. Trans.* No. 287.

Reliqua usus alimentique gratia genuit [Natura] ideoque secula annosque tribuit iis. Flores verò odoresque in diem gignit; magnâ (ut palam est) admonitione hominum, quæ spectatissimè florent, celerimè marcescere.—"Other plants are formed for use and for the purposes of aliment; and to these Nature has assigned a long duration of existence. But flowers, whose chief excellence is their odour, have a very short duration and live but for a day; an admonition to man that what is most beautiful to the sight is doomed the soonest to wither and decay."—*Plin. Nat. Hist.* l. 21. c. 1.

(*b*) As to the curious and gradual process of Nature in the formation of the seed or fruit of vegetables, cuts being necessary, I shall refer to Dr. Grew, p. 45. 209. and Malpig. p. 57.

* The fecundity of many plants is most astonishing. A single stalk of *Indian Turkey* wheat produces in one summer 2000 seeds; of elecampane 3000; of sun-flower 4000; of poppy 32,000. A single fruit or seed-vessel of tobacco contains 1000 seeds; a single head of poppy 8000. Mr. Ray found by experiment 1012 tobacco seeds were equal in weight to one grain; and thence computed, from the weight of the whole quantum of seeds in a single tobacco plant, that the number of seeds must have been 360,000. The same author estimates the annual produce of a single stalk of spleen-wort to be upwards of one million of seeds. EDITOR.

† See note of the EDITOR at the end of this chapter.

to the naked eye (*i*). And forasmuch as the perpetuity and safety of the species depends upon the safety

(*i*) *Vetus est Empedoclis dogma, plantarum semina ova esse, ab iisdem decidua. Inest in eo [ovo vel semine] velut in cicatrice, non sola viventis carina, sed cum minimo trunco assurgentes partes, gemma scilicet, & insignis radices canus, &c.*—"It was an old opinion of Empedocles that the seeds of plants were their eggs. In those eggs or seeds are contained the rudiments of the living plant, its trunk, its buds, and roots."—*Malpig. p. 81. vid. plura in tract. de Seminum Veget. p. 14. & passim.*

In *Malpighi's Life*, a debate may be seen between him and *Sign. Triumphetti*, the provost of the garden at *Rome*, whether the whole plant be actually in the seed. The affirmative is maintained by *Malpighi*, with cogent arguments; among which this is one: *Non præoccupatâ mente, oculis microscopio armatis, lustret queso phæseolorum seminalem plantulam nondum satam, in quâ folia stabilia, hæcque ampla evidenter observabit; in eadem pariter gemmam, nodos, seu implantationes varias foliorum caulibus deprehendet. Caulem insignem fibris ligneis, & utriculorum seriebus conflantem conspicuè attinget.*—"Let any one with an unprejudiced mind survey, by the help of a microscope, a seed of the kidney-bean before it is sown, and he will plainly observe in it the broad leaves, the buds, and the knots or insertions of the various stems. He will perceive the stalk distinguished by its woody fibres, and the rows of its vesicles."—(See *Pl. N. fig. 4.*) And whereas *S. Triumphetti* had objected, that *vegetatione, metamorphosi, inedia plantæ in alias degenerare, ut exemplo plurimum [constat] præcipuè tritici in lolium, & lolii in triticum versi.*—"By vegetation, by metamorphosis, by want of nourishment, one plant degenerates into another; as for example, wheat into darnel, and vice versa darnel into wheat."—In answer to this (which is one of the strongest arguments against *Malpighi's* assertion) *Malpighi* replies, *Nondum certum est de integritate, & successu experimenti, nam facienti mihi, & amicis, tritici metamorphosis non cessit. Admissa tamen metamorphosi, quoniam hæc neglecta cultura, aut vitio soli, aut aëris contingit—ideo ex morbofo & monstruoso affectu non licet inferre permanentem statum à Naturâ intentum. Observo plantas sylvestres culturâ*

Fig. 1.

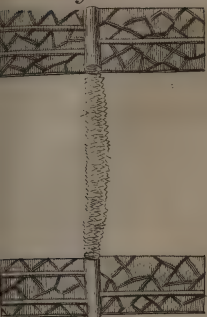


Fig. 3.



Fig. 2.

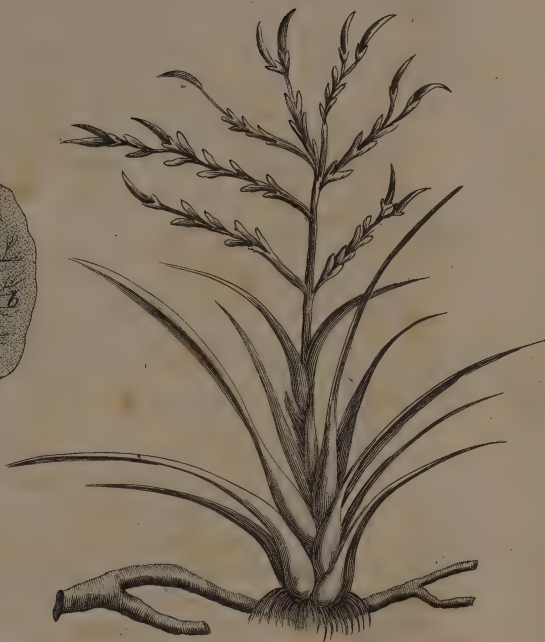


Fig. 4.

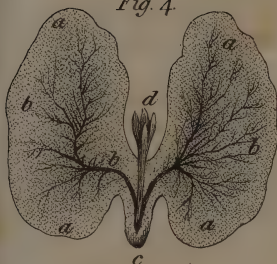


Fig. 1. The Tracheae or air-vessels in a Vine leaf.

Fig. 2. The wild Pine, a parasitical Plant of Jamaica, which grows on the branches and on the trunks of Trees.

Fig. 3. The young Tulip as it is found in the bottom of the root in winter.

Fig. 4. The rudiments of the future plant, as contained in a Bean, *a a* the Parenchyma or pulpy substance, which nourishes the seed-root, *b b* the seed-root which gives nutriment to the radicle or root of the plant, before it can draw nutriment from the Earth, *c* the Radicle or root, *d* the Plumule or Bud which contains the Stem, and leaves of the Plant, and which likewise draws nutriment from the seed-root, till the radicle is fitted to furnish it with juices from the Earth.

safety of the seed and fruit in a great measure,
I might therefore take notice of the peculiar care
the

culturâ varias reddi, &c.—"I am not sufficiently certain with regard to the authenticity or the event of the experiment; for in all the trials which either I or my friends have made, the change did not take place. And even admitting there were a change or metamorphosis of the one grain into the other, as this might have happened from negligence in the culture, fault of the soil or air, we ought not, from a morbid and preternatural affection of the plant, to infer a permanent state intended by Nature. I have observed wild plants produce great varieties from culture."—I have more largely taken notice of *Malpighi's* answer, because he therein shews his opinion about the transmutation of vegetables. *Vid. Malpig. Vit. p. 67.*

So Mr. *Lewenboeck*, after his nice observations of an orange-kernel, which he made to germinate in his pocket, &c. concludes, *Thus we see, how small a particle, no bigger than a coarse sand* (as the plant is represented) *is increased, &c. A plain demonstration that the plant, and all belonging to it, was actually in the seed, in the young plant, its body, root, &c.* *Philos. Transf. No. 287.* See also *Raii Cat. Cant. in Acer maj.* from Dr. *Higmore*. But in all the seeds which I have viewed, except the maple, the plant appears the plainest to the naked eye, and also very elegant, in the *Nux Vomica*.

Natura non observat magnitudinis proportionem inter semina & plantas ab iisdem ortas, ita ut majus semen majorem semper producat plantam, minus minorem. Sunt enim in genere herbarum non pauca, quarum semina arborum nonnullarum seminibus non dico aequalia sunt, sed multo majora. Sic v. g. semina fabæ, &c. semina ulmi, &c. multis vicibus magnitudine superant.—"Nature does not observe any certain proportion of size between plants and the seeds which produce them, as that the largest seed should always produce the largest plant, and *vice versa*. For there are many seeds of herbs which are not only equal in size to the seeds of trees, but much larger. Thus, for example, the seed of the bean far surpasses in magnitude the seed of the elm-tree."—*Raii, ubi supra, l. i. c. 13.*

the great God of Nature hath taken for the conservation and safety hereof. As particularly in such

Filicem reliquasque capillares herbas semine carere veteres plerique—prodidere, quos etiam secuti sunt è recentioribus nonnulli, Dodonæus, &c.—Alii è contrà, Bauhinus, &c. filices & congenere spermaphoras esse contendunt. Partim quia Historia Creationis, Genes. ii. 12, &c. Hanc sententiam verissimam esse—autopsia convincit.—“Most of the ancient writers maintained that the fern and other capillary plants had no seed; an opinion followed likewise by some of the moderns, as Dodonæus, &c. Bauhinus and others, however, maintained the contrary, and contended that the fern and all plants of that species bear seed; and my own observation convinces me that this opinion is true.”—*Fredericus Cæsius*, he saith, was the first that discovered these seeds with the help of a microscope; and since him, Mr. W. C. hath more critically observed them. Among other things observed by that ingenious gentleman are these: *Pixidulæ seu capsulæ semina continentes in plerisque hoc genus plantis perquam exili granulo arenæ vulgaris cinereæ plus duplo minores sunt; imò in nonnullis speciebus vix tertiam quartamve arenulæ partem magnitudine æquant, vesicularum quarundam annulis aut fasciis vermiformibus obvolutarum speciem exhibentes. Nonnullæ ex his vesiculis 100 circiter semina continere deprehendebantur—adè eximiâ parvitate ut nudo oculo prorsus essent invisibilia, nec nisi microscopii interventu detegi possent. Osimunda regalis, quæ aliis omnibus filicis speciebus mole—antecellit—vascula seminalia obtinet æquè cum reliquis congeneribus magnitudinis—quorum immensa & visum fugiens parvitas cum magnitudine plantæ collata—adè nullam gerere proportionem invenietur, ut tantam plantam è tantillo semine produci attentum observatorem meritò in admirationem rapiat.—*“The little cases or capsules which contain the seed in this species of plants are less than half the size of a very small grain of dust; nay in certain kinds they do not exceed the third or fourth part of such a grain, and resemble little bladders bound about with spiral twisting rings or filets. Some of these little bladders were found to contain about 100 seeds, so small as to be quite invisible to the naked eye, and only perceptible by help of the microscope. The *osimunda regalis*, which exceeds

such as dare to shew their heads all the year, how securely their flower, seed, or fruit is locked up all the winter, together with their leaves and branches, in their gems (*k*), and well fenced and covered there with neat and close tunicks. And for such as dare not so to expose themselves, with what safety are they preserved under the coverture of the

exceeds in magnitude of the plant all the other species of fern, has feminal vessels equally minute with the rest, and so disproportionate to its magnitude as to strike the beholder with astonishment."—*Raii, ubi supra*, l. 3. p. 132. This *W. C.* was Mr. Will. Cole, as he owneth in a letter I have now in my hands of his to Mr. Ray, of Octob. 18, 1684.

(*k*) *Vegetantium genus, ut debitam magnitudinem sortiatur, & suæ mortalitatis jacturam successivâ prolis educatione repararet, statim temporibus novas promittit partes, ut tandem emergentes uteri, recentes edant soboles. Emanantes igitur à caule, caudice, ramis, & radicibus novellæ hujusmodi partes, non illico laxatæ extenduntur, sed compendio quodam coagmentatæ intra folii axillam cubantes, non parum subsistunt, gemmæ appellantur, &c.*—"In order that the vegetable kingdom may maintain its just proportion to the other productions of Nature, and repair by the fecundity of its productions the successive decay of the individuals, each plant, at stated seasons, puts forth new parts, which, like so many matrices, are capable of producing new offspring. These parts are not immediately unfolded, but contain in a compressed form the rudiments of the future productions, and lying as it were under the arm-pits of the leaves, are called gems or buds."—*Malpig. de Gemmis*, p. 22.—And then that great man goes on to shew the admirable various methods of Nature, in repositing in that little compass, so large a part of a tree or plant, the curious structure of the gems, the admirable guard afforded them, and the leaves, flowers, and seed contained in them, &c. Of which having taken notice before, I pass over it now, and only refer to our author *Malpighi*, and Dr. *Grew*, in the places recited in *note (f)* and (*g*).

the earth, in their root (*l*), seed (*m*), or fruit, till invited out by the kindly warmth of the spring!
And

(*l*) Of *bulbous*, and a great many more, probably of the far greater number of *perennial roots* of herbs, as *arum*, *rape-craw-foot*, &c. it is very observable, that their root is annually renewed, or repaired out of the trunk or stalk itself; that is to say, the *basis* of the *stalk* continually, and by insensible degrees descending below the surface of the earth, and hiding itself therein, is thus both in nature, place, and office, changed into a true root.—So in *Brownwort*, the basis of the stalk sinking down by degrees, till it lies under ground, becomes the upper part of the root; and continuing still to sink, the next year becomes the lower part; and the next after that, rots away; a new addition being still yearly made out of the stalk, as the elder parts yearly rot away. *Grew*, *ibid.* l. 2. p. 59. *ubi plura vid.*

(*m*) How safe and agreeable a conservatory the earth is to vegetables, more than any other, is manifest from their rotting, drying, or being rendered infecund in the waters or the air; but in the earth their vigour is long preserved. Thus seeds particularly, Mr. Ray thinks some, may probably retain their fecundity for ten years, and others lose it in five; but, saith he, *In terræ gremio laitantia, quamvis tot calor, frigoris, humoris & siccitatis varietatibus ibidem obnoxia, diutius tamen (ut puto) fertilitatem suam tuentur quàm ab hominibus diligentissimè custodita; nam & ego & alii ante me multi observârunt sinapeos vim magnam enatam in aggeribus fossarum recens facilis inque areis gramineis effossis, ubi post hominum memoriam nulla unquam sinapeos seges succreverat. Quam tamen non spontè ortam suspicor, sed è seminibus in terrâ per tot annos residuis etiam prolificis.*—“ These seeds lying hid in the earth, although exposed to such variations of heat, cold, dryness, and moisture, retain, as I imagine, their fecundity much longer than when preserved by the utmost care of man; for both myself and others have observed a great crop of mustard sprung up on the mounds of ditches newly dug, and in grassy plots

And when the whole vegetable race is thus called out, it is admirable to observe the methods of Nature in guarding those insensitive creatures against harms and inconveniencies, by making some (for instance) to lie down prostrate, and others to close themselves up (*n*) upon the touch of animals, and the most to shut up their flowers, their down (*o*), or other

plots when dug up, where no mustard had been known to grow within the memory of man. I have no idea that those plants were spontaneously produced, but believe that they have grown from seeds lying long concealed in the earth, but still retaining their prolific powers.”—*Ray Hist. Pl. l. i. c. 13.*

(*n*) *Plantæ nonnullæ aschynomænæ veteribus dictæ; recentioribus vivæ, & sensitivæ, & mimosæ, haud obscura sensûs indicia prædunt; siquidem folia earum manu aut baculo tacta, & paululum compressa, pleno etiam meridie, splendente sole, illico se contrahunt; in nonnullis etiam speciebus cauliculi teneriores concidunt & velut marcescunt; quod idem ab aëre frigidiore admissio patiuntur.*—“Those plants termed *aschynomænæ* by the ancients, but which we call living, sensitive, or mimous, exhibit no obscure marks of sensation; for their leaves, when touched by the hand or with a stick, and a little compressed, immediately contract although at noon-day and in sun-shine: in some species the tender stem falls down apparently drooping, which likewise happens when they are exposed to a blast of cold air.”—*Ray Hist. Pl. t. i. l. 18. App. f. 2. c. 2. p. 978.*

(*o*) I have observed that many, if not most vegetables, do expand their flowers, down, &c. in warm, sun-shiny weather, and again close them towards evening, or in rain, &c. especially at the beginning of flowering, when the seed is young and tender; as is manifest in the down of *dandelion* and other downs; and eminently in the flowers of *pimpernel*, the opening and shutting of which are the countryman’s weather-wiser; whereby

other their like guard, upon the close and cool of the evening, by means of rain or other matters that may be prejudicial to the tender seed *.

And now to these considerations relating to the seed, I might add the various ways of Nature in dissipating and sowing it, some being for this end winged with light down, or wings, to be conveyed about by the winds; others being laid in elastic, springy cases, that when they burst and crack, dart their seed at convenient distances, performing thereby

Gerard saith, he foretellet what weather shall follow the next day; for, saith he, *If the flowers be close shut up, it betokeneth rain and foul weather; contrariwise, if they be spread abroad, fair weather.* Ger. Herb. b. 2. c. 183.

Est & alia [arbor in tyli] similis, foliosior tamen, roseique floris; quem noctu comprimens, aperire incipit solis exortu, meridie expandit. Incolæ dormiro eam dicunt.—"There is likewise another plant among the tyli, but more leafy and of a rosy colour, which closes in the night-time, begins to open at sun-rise, and expands at noon-day. It is vulgarly called *dormiro*."—*Plin. Nat. Hist.* l. 12. c. 11.

* It is observed by Dr. Darwin, that the flowers or petals of plants are in general more acrid than their leaves; and hence they are much seldomer devoured by insects. All essential oils of plants are destructive to insects, and hence their use in the vegetable œconomy, to protect the flowers or leaves from the depredations of their voracious enemies. The nauseous or pungent juices of some plants serve the same useful purpose; and even the strong smell of certain vegetables is a part of their defence. There are some plants, as the *tropæolum*, garden nasturtium or Indian cress, which emit electrical scintillations, which probably answer the same beneficial end. EDITOR.

thereby the part of a good husbandman (*p*); others by their agreeable taste and smell, and salutary nature,

(*p*) So soon as the seed is ripe, Nature taketh several methods for its being duly sown; not only in the opening of the uterus, but also in the make of the seed itself. For, first, The seeds of many plants, which affect a peculiar soil or seat, as of arum, poppy, &c. are heavy and small enough, without farther care, to fall directly down into the ground. But if they are so large and light as to be exposed to the wind, they are often furnished with one or more hooks, to stay them from straying too far from their proper place. So the seeds of avens have one single hook; those of agrimony and goosegrasses, many; both the former loving a warm bank; the latter, an hedge for its support. On the contrary, many seeds are furnished with wings or feathers; partly with the help of the wind to carry them, when ripe, from off the plant, as of ash, &c. and partly to enable them to make their flight more or less abroad, that so they may not, by falling together, come up too thick; and that if one should miss a good soil or bed, another may hit. So the kernels of pine have wings—yet short—whereby they fly not into the air, but only flutter upon the ground. But those of typha, dandelion, and most of the pappous kind, have long numerous feathers, by which they are waisted every way. Again, there are seeds which are scattered not by flying abroad, but by being either spirted or flung away. The first of those are wood-sorrel, which having a running root, Nature sees fit to sow the seeds at some distance. The doing of which is effected by a white sturdy cover, of a tendinous or springy nature. This cover, so soon as it begins to dry, bursts open on one side, in an instant, and is violently turned inside outward, and so smartly throws off the seed. The seeds of harts-tongue is flung or shot away, by the curious contrivance of the seed-case, as in codded asmart, only there the spring moves and curls inward, but here outward, viz. every seed-case is of a spheric figure, and girded about with a sturdy spring. The surface of the spring resembles a fine screw. So soon as this spring is become stark enough, it suddenly breaks the case into two halves, like two little cups, and so flings the seed. Grew, *ib.* p. 199. and in *tab.* 72. all these admirable artifices are handsomely represented.

ture, inviting themselves to be swallowed, and carried about by the birds, and thereby also fertilized by

Quin si quantitas modica seminum (filicis phyllitidis quoque) à foliis in subiectam chartæ mundæ—schedam decutiatur, detergaturve, & deinde in acervum converratur, vesicularum seminalium plurimis una diffilientibus, & sibi invicem allisis, acervulus variè moveri per partes videbitur, non secus ac si syrenibus aut istiusmodi bestiolis repletus esset—quin si locus tranquillus sit, aure proximè admotâ, crepitantium inter rumpendum vasculorum sonitus—percipietur; & si microscopio chartam oculis oberres, semina per eam undique sparsa, & ad notabilem ab acervò distantiam projecta comperies.—
 “If a moderate quantity of the seeds of the fern *phyllites* be shaken off upon a sheet of white paper, wiped, and gathered into a heap, by the seminal vesicles starting asunder and striking each other, the whole heap will appear to be in motion in several parts, as if filled with small insects: and if the place is quiet, by approaching the ear to the heap, one may hear the sound of the little vesicles crackling as they burst, and observe the seeds flying off, scattered at a considerable distance from the heap.”—*Ray's Hist. Pl.* p. 132.

The admirable contrivance of Nature in this plant is most plain. For the seed-vessels being the best preserver of the seed, it is there kept from the injuries of air and earth, until it be rainy, when it is a proper time for it to grow, and then it is thrown round the earth, as grain by a skilful sower.—When any wet touches the end of the seed-vessels, with a smart noise and sudden leap it opens itself, and with a spring scatters its seed to a pretty distance round it, where it grows. *Dr. Sloane Voy. to Jamaica, p. 150. of the gentianella flore ceruleo, &c. or spirit-leaf.*

The plants of the *cardamine-family*, and many others, may be added here, whose pods fly open, and dart out their seed, upon a small touch of the hand. But the most remarkable instance is in the *cardamine impatiens*, *cujus siliquæ* (saith Mr. Ray) *vel leviter tactæ, adutùm ejaculantur* [semina] *inò, quod longè mirabilius videtur, etsi siliquas non tetigeris, si tamen manum velut tacturus proximè admoveas, semina in appropinquantem evibrabunt; quod tum Mori-*
 sonus

by passing through their bodies (*q*); and others not thus taken care of, do many of them by their usefulness

sonus se sæpius expertum scribit, tum Johnstonus apud Gerardum verum esse affirmat.—"The impatient cardamine, whose pods when slightly touched immediately explode; and what is still more wonderful, although one does not touch the pods, but only move the hand towards them, as if going to touch them, the seeds will fly out at its approach; an experiment which both Morison declares he has often tried, and Johnston and Gerard affirm to be true."—*Hist. Plant.* l. 16. c. 20.

Neither is this provision made only for land vegetables, but for such also as grow in the sea. Of which I shall give an instance from my before-commended friend, Dr. Sloane. *As to the fuci, their seed hath been discovered (and shewed me first) by the industry of the ingenious herbarist Mr. Sam. Doody, who found on many of this kind solid tubercles, or risings in some seasons, wherein were lodged several round seeds, as big as mustard-seed, which, when ripe, the outward membrane of the tubercle breaking, leaveth the seed to float up and down with the waves. The seed coming near stones, or any solid foundation, by means of a mucilage it carries with it, sticks to them, and shoots forth ligulæ with branches, and in time comes to its perfection and magnitude.* Sloane Voy. Jamaica, p. 50.

But although Mr. Doody had hinted, and conjectured at the thing; yet the first that discovered the seeds in *fuci*, was the before-commended Dr. Tancred Robinson; as may be seen by comparing what Mr. Ray saith in his *Synops. Stirp. Brit.* p. 6. with his *Append. Hist.* p. 1849. Besides which *fuci*, the Dr. tells me, he observed vessels and seed in *coralloid shrubs* *, as also in several *fungi*,

* The corals and corallines were formerly believed to be vegetable substances; but they are now known to be the shells or matrices of animals of the polype kind; some consisting of a single tube which is inhabited by one worm, others of a great congeries of tubes, each containing its distinct animal. Other genera

fulness in human life, invite the husbandman and gardener carefully to sow and nurse them up.

To

fungi, not only in the species of *crepitus lupi*, but also between the *lamella* of other species, and in that subterraneous kind called *truffles*, whose seed and vessels open in the cortex, at some seasons, he saith, like that of mallows in shape.

As to the *crepitus lupi*, I have more than once examined their powder, with those excellent microscopes of Mr. *Wilson*'s make : but the most satisfactory view Mr. *Wilson* himself gave me ; by which I found the seeds to be so many exceeding small *puff-balls* with round heads, and longer than ordinary sharp-pointed stalks, as if made on purpose to prick easily into the ground. These seeds are intermixed with much dusty matter, and become hurtful to the eyes, probably by their sharp stalks pricking and wounding that tender organ.

(q) The ancient naturalists do generally agree, that *mistletoe* is propagated by its seeds carried about by, and passing through the body of birds. Thus *Theophrastus de Caus. Plant.* l. 2. c. 24. Τὸ δὲ ἀπὸ σῆς ἐκείνου, &c. *Initium verò à pastu avium :—*Quippe visco detracto confectoque in alveis, quod frigidissimum est, semen cum excremento purum dimittitur, & factâ mutatione aliquâ in arbore stercoreis causâ pullulat, erumpitque, &c.—“ It proceeds from the food of birds ; for the mistletoe being plucked and concocted in the stomach and bowels of the bird, the seed which is of a very cold nature is voided pure along with the excrement, and being cherished by the dung which makes a change upon the tree, it there springs and vegetates.”—So also *Pliny* saith, viz. *Omnino autem satum [viscum] nullo modo nascitur, nec nisi per alvum avium redditum,*

genera of marine productions, which have all the appearance of plants, and were formerly considered as such, are found in like manner to be the nests of sea animals, to which they bear the same relation as the shell does to the snail which inhabits it. Such are the heratophyta, eschara, sponges, and alcyonium.

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To this so singular a care about the propagation and conservation of the species of vegetables, I might

redditum, maximè palumbis ac turdi. Hæc est natura, ut nisi maturatam in ventre avium, non proveniat.—"The mistletoe never springs when sown, unless first voided by birds, especially by wood-pigeons and thrushes. For it requires to be matured in the bowels of birds."—*Plin. N. H. l. 16. c. 44.* Whether what *Theophrastus* and *Pliny* affirm, be conducive to the better fertilizing the seeds of *mistletoe*, I know not; but that it is not of absolute necessity, I can affirm upon mine own experience, having seen the seeds germinate, even in the bark of oak. But although they shot above an inch, and seemed to root in the tree, yet they came to nothing, whether destroyed by ants, &c. which I suspected, or whether disagreeing with the oak, I know not. But I since find the matter put out of doubt by Mr. *Doody*; which see in Mr. *Ray's Hist. Plant. App. p. 1918.*

Nutmegs are said to be fertilized after the same manner, as *Tavernier* saith was confirmed to him by persons that lived many years in those parts; whose relation was: the *nutmeg* being ripe, several birds come from the islands toward the south, and devour it whole, but are forced to throw it up again, before it be digested: and that the *nutmeg*, then besmeared with a viscous matter, falling to the ground, takes root, and produces a tree, which would never thrive, was it planted. *Tavern. of the Commod. of the G. Mogul.* And Monsieur *Thevenot*, in his Travels to the *Indies*, gives this account: the tree is produced after this manner; there is a kind of birds in the island, that having picked off the green husk, swallow the nuts, which having been some time in their stomach, they void by the ordinary way; and they fail not to take rooting in the place where they fall, and in time grow up to a tree. This bird is shaped like a *cuckoo*; and the *Dutch* prohibit their subjects, under pain of death, to kill any of them. *Vide Sir T. Pope-Blount's Nat. Hist.*

But Mr. *Ray* gives a somewhat different account: *Hunc fructum* [nucem moschatam] *varie quidem aves depascuntur, sed maximè columbæ genus album & parvum, quæ dehiscente nucamento,*

might add the nice provision that is made for their support and aid, in standing and growing, that they may keep their heads above ground, and not be rotted and spoiled in the earth themselves, nor thereby annoy us ; but, on the contrary, minister to all their ends, and our uses ; to afford us houses, utensils, food (r), physic, clothing, yea, diversion too,

illectæ suavitæ macis, hunc cum nuce eripiunt & devorant, nec nisi repletâ ingluvie capacissimâ saginam deferunt. Nosstrates ibi mercatores columbis istis nut-eaters sive nucivoris nomen imposuerunt. Quas autem vorant nuces, post integras per alvum reddunt. Redditæ citiùs deinde germinant utpote præmaceratæ fervore ventriculi. Arbores inde natæ ceu præcociiores, facilè sunt corruptioni obnoxie fructumque ferunt cæteris multo viliores, & hâc causâ neglectum incolis contentumque, præter macin, quem ad adulterandum meliorem adhibent.—“ This fruit (the nutmeg) is fed upon by various birds, but chiefly by a kind of small white pigeon, which, when the covering of the nut splits open, being allured by the sweetness of the mace, pluck it off, together with the nut, and devour it ; and never cease swallowing till they are perfectly stuffed. The merchants of our country call these birds nut-eaters. The nuts which they swallow are voided entire, and being macerated by the heat of the stomach, vegetate the quicker. But the trees which are thence produced are more liable to rottenness, and bear a very inferior species of fruit, which is therefore despised and neglected by the natives, except the mace, which they use for adulterating what is of a better quality.”—Ray’s *H. P.* l. 27.

C. 4.

(r) *Arbores blandioribus fruge succis hominem mitigavere. Ex his recreans membra olei liquor, viresque potus vini ; tot denique saporis annui sponte venientes : & mensæ depugnetur licet earum causa cum feris, & pastis naufragorum corporibus pisces expetantur, etiamnum tamen secundæ. Mille præterea sunt usus earum, sine quibus vita degi non possit. Arbore fulcamus maria, terrasque admovemus, arbore exedificamus tecta.*—“ The trees have supplied many with milder

too, by the beauty of their looks, by the fragrancy of their smell, by creating us pleasant shades against the scorching beams of summer, and skreening us against the piercing winds and cold of winter (s).

And

milder juices than those of grain. From them we derive the oil so refreshing to our bodies, and the strengthening and exhilarating wine. Of them we make our tables serviceable to man, though to supply them with luxuries he fights with the wild beasts, and feeds the hungry fishes with the shipwrecked carcases of the mariners. Numberless are their necessary uses to the purposes of life. By means of trees we plough the ocean, approximate distant lands, and build for ourselves habitations *."—*Plin. N. H. l. 12. c. 1.*

(s) *Plantarum usus latissime patet, & in omni vitæ parte occurrit. Sine illis lautè, sine illis commodè non vivitur, at nec vivitur omnino : quæcunque*

* In the Ladrone island and some of the Philippines, as also in the newly-discovered islands of the South Sea, the inhabitants are supplied with bread, not from any species of grain, but from a tree which is called rima, or mahie, and by our naturalists *artocarpus*, or the bread fruit. This tree is about the size of a middle-sized oak, with leaves of a foot and a half in length, indented like those of the fig-tree. The fruit, says Captain Cook, is about the size of a child's head, and its surface reticulated not unlike a truffle; it is covered with a thin skin: the inner part is as white as snow, and somewhat of the consistence of new bread. It is roasted on the coals or baked in an oven till the rind is black, and then cut into slices, which are either eaten when fresh and soft, or dried in the sun till they become hard like biscuit, in which state the bread may be kept a long time. It has a sweetish taste, somewhat like the Jerusalem artichoke. It is likewise made into puddings, and sometimes boiled with fresh meat, or fried with oil like fritters. This fruit is in season for about eight months in the year, and abundantly supplies the place of all other farinaceous vegetables.

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And it is very observable what admirable provisions are made for this purpose of their support and standing,

quæcunque ad victum necessaria sunt, quæcunque ad delicias faciunt, è locupletissimo suo penu abundè subministrant. Quanto ex iis mensa innocentior, mundior, salubrior quàm ex animalium cæde & lanienâ? Homo certè naturâ animal carnivororum non est; nullis ad prædam & rapinam armis instructum, non dentibus exertis & ferratis, non unguibus aduncis. Manus ad fructus colligendos, dentes ad mandendos comparati. Non legimus ei ante diluvium carnes ad esum concessas. At non victum tantum nobis suppedulant, sed & vestitum, & medicinam & domicilia aliaque ædificia, & navigia, & supellectilem, & focum, & oblectamenta sensuum animique: ex his naribus odoramenta & suffumigia parantur. Horum flores inenarrabili colorum & schematum varietate, & elegantia, oculos exhilarant, suavissima odorum quos expirant fragrantia spiritus recreant. Horum fructus gulæ illecebræ mensas secundas instruunt, & languentem appetitum excitant. Taceo virorem amænissimum oculis amicum, quem per prata, pascua, agros, sylvas, spatiantibus obijciunt, & umbras quas contra æsum & solis ardores præbent.—“The uses of plants are most various and extensive in every department of human life. Without them we can neither live comfortably nor conveniently; nay we could not live at all. They furnish us in abundance whatever is necessary for our food, whatever supplies us with delicacies. How much more innocent our repast, how much cleaner, how much more wholesome than what is furnished by the slaughter and butchery of animals? Man certainly is not by nature a carnivorous animal; he is furnished with no arms for prey or rapine; he has neither prominent and serrated tusks, nor crooked claws. He has only hands for gathering the fruits of the earth, and teeth for chewing them. We read not that he ever eat flesh before the deluge. But plants furnish us not only with food; they supply us with clothes, with medicines, with habitations and other structures, with ships, with furniture, with fire, with numberless gratifications to the senses and to the mind. The sense of smelling is refreshed with their odours; their flowers with the variety and beauty of their forms and colours delight the sight. Their fruits furnish our desserts, and stimulate our languid appetite.

standing, both in such as stand by their own strength, and such as need the help of others. In such as stand by their own strength, it is by means of the stronger and more ligneous parts (equivalent to the bones in animals) being made not inflexible as bones, because they would then be apt to break; but of a yielding elastic nature, to escape and dodge the violence of the winds; and by means also of the branches spreading handsomely and commodiously about, at an angle of about 45 gr. by which means they equally fill up, and at the same time make an equilibration of the top (*t*).

And

appetite. I need not mention that most delightful verdure which is so friendly to the eye-sight, and which meets us in our walks through the meads, the pastures, the fields, and woods; nor the grateful shade they furnish against the scorching rays of the sun."—*Ray's H. P.* l. i. c. 24. p. 46.

(*t*) All vegetables of a tall and spreading growth seem to have a natural tendency to a hemispherical dilation, but generally confine their spreading within an angle of 90 gr. as being the most becoming and useful disposition of its parts and branches. Now the shortest way to give a most graceful and useful filling to that space of dilating and spreading out, is to proceed in straight lines, and to dispose of those lines in a variety of parallels, &c. And to do that in a quadrantal space, &c. there appears but one way possible, and that is, to form all the intersections, which the shoots and branches make, with angles of 45 gr. only. And I dare appeal to all if it be not in this manner almost to a nicety observed by Nature, &c. A visible argument that the plastic capacities of matter are governed and disposed by an all-wise and infinite Agent, the native strictnesses and regularities of them plainly shewing from whose hand they come. *Account of the Origin and Format. of Foss. Shells, &c.* print. Lond. 1705, p. 38, 41.

And as for such vegetables as are weak, and not able to support themselves, it is a wonderful faculty they have, so readily and naturally to make use of the help of their neighbours, embracing and climbing up upon them (u), and using them as crutches to their

(u) *In hederâ, furculi & rami hinc inde claviculos, quasi radículas emittunt, quæ parietibus, vel occurrentibus arboribus veluti digitis firmantur, & in altum suspenduntur. Hujusmodi radicula subrotundæ sunt, & pilis coperiuntur; & quod mirum est, glutinosum fundunt humorem, seu terebinthinam, quâ arte lapidibus neantur & agglutinantur.*—Non minori industriâ natura utitur in vite Canadensi, &c.—“ In the ivy, the small branches and twigs put forth creeping fibres or roots, which lay firm hold on the trees or walls which they encounter, and by these the plant is suspended. These roots are roundish and covered with hairs; and what is very remarkable, they exude a glutinous liquor or turpentine, by which they adhere and glue themselves close to the stones. A no less admirable contrivance is to be remarked in the Canadian vine, &c.”—The admirable and curious make of whose tendrils and their feet, see in the illustrious author *Malpig. de Capreolis*, &c. p. 48.

Claspers are of a compound nature, between that of a root and a trunk. Their use is sometimes for support only; as in the claspers of vines, briony, &c. whose branches being long, slender, and fragile, would fall by their own weight, and that of their fruit; but these claspers taking hold of any thing that is at hand, which they do by a natural circumvolution which they have (those of briony have a retrograde motion about every third circle, in the form of a double clasp; so that if they miss one way, they may catch the other). Sometimes the use of claspers is also for a supply, as in the trunk-roots of ivy; which being a plant that mounts very high, and being of a closer and more compact substance than that of vines, the sap would not be sufficiently supplied to the upper sprouts, unless these assisted the mother-root; but these serve also for support too. Sometimes also they serve for stabiliment, propagation, and shade; for the first of these serve the claspers of cucumbers; for the second, those,

their feeble bodies: some by their odd convolving faculty, by twisting themselves like a screw about others; some advancing themselves, by catching and holding with their curious *claspers* and *tendrils*, equivalent to the hands; some by striking in their rooty feet *, and others by the emission of a natural

those, or rather the trunk-roots of *chamomil*; and for all three the trunk-roots of *strawberries*. *Harris Lex. Tech.* in verb. *Claspers*.

* Plants are endowed with the power of directing their roots in search of proper nutriment. The red whortle-berry, a low evergreen, grows naturally among gravel on the tops of hills. This shrub was planted in an edging to a rich border under a fruit wall. In two or three years it overran the adjoining deep-laid gravel-walk, and seemed to fly from the border in which not a single runner appeared. Among the ruins of New Abbey in Galloway, there grows on the top of a wall a planetree about 20 feet high. Straitened for nourishment in that barren situation, it several years ago directed roots down the side of the wall, till they reached the ground 10 feet below; and now the nourishment it afforded to those roots, during the time of their descending, is amply repaid, the tree having every year since that time made vigorous shoots. From the top of the wall to the surface of the earth these roots have not thrown out a single fibre, but are now united in a single root. Plants, when forced from their natural position, are endowed with a power to restore themselves. Twist a branch of a tree so as to invert its leaves, and fix it in that position; if left in any degree loose, it untwists itself gradually till the leaves be restored to their natural position. A root of a tree meeting with a ditch in its progress, alters its course, and sometimes dips under the ditch and rises in the same direction on the opposite side. Thrust a pole into the ground

ral glue, closely and firmly adhering to something or other that administers sufficient support unto them. All which various methods being so nicely accommodated to the indigencies of those helpless vegetables, and not to be met with in any besides, is a manifest indication of their being the contrivance and work of the Creator, and that his infinite wisdom and care condescends, even to the service and well-being of the meanest, most weak, and helpless insensitive parts of the creation.

In the last place, to the uses already hinted at, I might add a large catalogue of such among vegetables as are of peculiar use and service to the world, and seem to be designed as it were on purpose, by the most merciful Creator, for the good of man or other creatures (*w*). Among grain, I might name the great fertility (*x*) of such as serves for

(*w*) Vegetables afford not only food to irrationals, but also physic, if it be true which *Aristotle* saith, and after him *Pliny*; which latter in his 8th book, chap. 27. specifies divers plants made use of as specifics, by divers, both beasts and birds: as *dittany* by wounded deer; *celandine* by swallows, to cure the sore eyes of their young, &c. And if the reader hath a mind to see more instances of this nature, (many of them fanciful enough,) he may consult *Mersenne in Genes.* p. 933.

(*x*) See before, book iv. chap. 11. note (*b*).

near a scandent plant, and it will direct its tendrils towards it and climb up. A honeysuckle, if it finds no other support, turns itself into spirals, two or three twigs convolving themselves together, and thus supporting each other.

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for bread, the easy culture and propagation thereof, and the agreement of every soil and climate to it. Among trees and plants, I might instance in some that seem to be designed, as it were, on purpose, for almost every use (*y*) and convenience; some to heal

(*y*) *Planta hæc unica*, [*aloe Americana*,] inquit *Fr. Hernandez*, quicquid vitæ esse potest necessarium præstare facile potest, si esset rebus humanis modus. Tota enim illa lignorum sepiendorumque agrorum usum præstat, caules tignorum, folia verò tecta tegendi imbricum, lancium: eorundem nervuli, & fibræ eundem habent usum ad lintamina, calceos, & vestimenta conficienda quem apud nos linum, cannabis, gossypium, &c. E mucronibus sunt clavi, aculei, subulæ, quibus perforandis auribus, macerandi corporis gratiâ, indies uti mos erat cum demonum vacarent cultui; item aciculæ, acus, tribuli militares & rastilla idonea pedendis subtegminibus. Præterea è succo mananti, cujus evulsis germinibus internis foliisque tenerioribus cultis [*Yztlinis*] in mediani cavitatem, stillat planta, unica ad 50 interdum amphoras (quod dictum est mirabile) vina, mel, acetum, ac saccharum parantur [the methods of which he tells]. Idem succus menses ciet, alvum lenit, urinam evocat, renes & vesicam emundat. E radice quoque restes fiunt firmissimæ. Crassiores foliorum partes, truncusque, decocta sub terrâ, edendo sunt apta, sapiuntque citrea frustra saccharo condita: quin & vulnera recentia mirè conglutinant.—Folia quoque assa & affecto loco imposita convulsionem curant, ac dolores leniunt (præcipuè si succus ipse calens bibatur) quamvis ab indicâ proficiantur lue, sensum hebetant, atque torporem inducunt. Radicis succus lue veneream curat apud Indos ut *Dr. Palmer*.—"This single plant, (the American aloe,) says Hernandez, is capable of supplying easily whatever is necessary for the purpose of life, if indeed there were any bounds to the desires of man. For the entire plant serves the purpose of a hedge, its stems are used for beams or joints, its leaves for tiles and platters: its slender fibres are put to the same uses as flax, hemp, or cotton-thread for making cloths, shoes, and garments. From its sharp points are made nails, bodkins, awls, caltrops, little

heal the most stubborn and dangerous distempers (z), to alleviate and ease the pains (aa) of our poor

little harrows or cards for manufacturing cloth. Besides, from the juice of the plant, which distills when the buds are torn off, sometimes to the astonishing quantity of 50 amphoræ (or firkins) from a single plant, wine, honey, vinegar, and sugar are prepared. The same juice has the medicinal qualities of removing obstructions in women, of purging and exciting urine, and of cleansing the reins and bladder. From its roots are likewise made the strongest ropes and cables. The thicker parts of the leaves and the stem when macerated under ground, are fit for eating, and taste like pieces of citron preserved with sugar. They likewise are excellent for the healing of green wounds. The boiled leaves, when externally applied, cure convulsions, (and still more effectually if the juice is drank warm,) and they ease the pains produced from the *lues venerea*. The juice of the root, says Dr. Palmer, cures the Indians of the *lues venerea*."—*Ray's H. P.* l. 21. c. 7. See also Dr. Sloane's *Voyage to Jamaica*, p. 247.

There are also two sorts of *aloe* besides, mentioned by the same Dr. Sloane, one of which is made use of for fishing-lines, bow-strings, stockings, and hammocks. Another hath leaves that hold rain-water, to which travellers, &c. resort to quench their thirst in scarcity of wells or waters in those dry countries. *Ibid.* p. 249.

(z) For instance here, I shall name the *cortex Peruvianus*, which Dr. Morton calls *Antidotus in levamen ærumnarum vitæ humane plurimarum divinitus concessa*. De Febr. Exer. v. c. 3. *In sanitatem gentium proculdubio à Deo O. M. conditus. Cujus gratiâ, arbor vitæ, siqua alia, jure meritò appellari potest.* Id. ib. c. 7. *Eheu! quot convitiis herculea & divina hæc antidotus jactabatur?*—"An antidote for all the diseases incident to human nature, and certainly sent us from above: framed by the Almighty himself for the benefit of mankind. On which account it merits more than any other plant the appellation of the tree of
of

poor infirm bodies, all the world over: and some designed for the peculiar service and good of particular places, either to cure such distempers as are peculiar to them, by growing more plentifully there than elsewhere (*bb*), or else to obviate some incon-

of life. Yet, how much have the virtues of this most powerful, nay divine antidote been slandered?"—*Ibid.*

To this (if we may believe the *Ephemer. German. Ann.* 12. *Obfer.* 74. and some other authors) we may add *trifolium paludosum*, which is become the *panacea* of the German and northern nations.

(*aa*) *Pro doloribus quibuscunque sedandis præstantissimi semper usus opium habetur; quamobrem meritò nepenthe appellari solet, & remedium verè divinum existit. Et quidem satis mirari vix possumus, quomodo urgente visceris aut membri cujuscumque torturâ insigni, & intolerabili cruciatu, pharmacum hoc, incantamenti instar, levamen & αναλγησιαν subitam, immò interdum absque somno, aut saltem prius quàm advenzerit, concedit. Porro adhuc magis stupendum est, quod donec particula opiatice operari, & potentiam suam narcoticam exercere continuant, immò etiam aliquamdiu postquam somnus finitur, summa alleviatio, & indolentia in parte affectâ persistit.*—"Opium is esteemed of the most sovereign virtue for relieving all manner of pains; whence it may be esteemed a divine remedy, and is deservedly called nepenthe. And indeed we cannot sufficiently admire how this wonderful medicine, operating like enchantment, eases the most acute pains of the bowels, or torment of the limbs, and that often without producing sleep, or before sleep comes on. It is likewise most worthy of admiration, that while its particles continue to exert their narcotic influence, and after the sleep is finished, the greatest ease and alleviation of pain continues in the parts affected."—*Willis, Phar. rat.* Par. 1. S. 7. cap. 1. sect. 15.

(*bb*) *Tales plantarum species in quacunque regione à Deo creantur quales hominibus & animalibus ibidem natis maximè conveniunt;*
imò

inconvenience there *, or to supply some constant necessity or occasion, not possible, or at least not easy,

imò ex plantarum nascentium frequentia se fere animadvertere posse quibus morbis [endemiis] qualibet regio subiecta sit, scribit Solenander. Sic apud Danos, Frisios, Hollandos, quibus, scorbutus frequens, cochlearia copiosè provenit.—“ Such species of plants are formed by the Creator in every country as are most adapted to the constitution of its inhabitants; nay, from the frequency of those plants which a country produces, we may, as Solenander observes, most commonly form a just opinion with regard to the endemial diseases to which it is subject. Thus among the Danes, Frieslanders, and Dutch, where the scurvy is a frequent disease, we observe great quantities of scurvy-grass.”—*Ray's H. Pl.* lib. 16. cap. 3.

To this may be added, *Elfner's* observations concerning the virtue of divers things, in his observations *de vincetoxico scrophularum remedio*. F. Germ. T. 1. Obs. 57.

John Benorovinus, a physician of *Dort*, may be here consulted, who wrote a book on purpose to shew, that every country hath every thing serving to its occasions, and particularly remedies afforded to all the distempers it is subject unto. See *Bener. 'Ανταρκτικα. Batav. sive Introd. ad Medic. indigenam*.

* The leaf of the rattlesnake-root (*polygala senega*) is the most efficacious remedy against the bite of this dreadful animal; and it is observed by the author who relates this property of the plant, that “ Almighty God has mercifully granted it to grow in the greatest plenty in all those parts that are most infested by the rattlesnake; and it is remarkable that the herb acquires its greatest perfection just at the time when the bite of those serpents is most dangerous. The Indians,” continues he, “ are so well convinced of the certainty of this antidote, that many of them will suffer themselves to be bitten for a glass of brandy.” *Loskiel's History of the Mission of the United Brethren among the Indians in North America.* EDITOR.

easy, to be supplied any other way (*cc*). It is, for instance, an admirable provision made for some countries subject to drought, that when the waters every where fail, there are vegetables which contain not only moisture enough to supply their own

vegetation

(*cc*) The description Dr. *Sloane* gives of the *wild-pine* is, that its leaves are channelled, fit to catch and convey water down into their reservoirs; that these reservoirs are so made as to hold much water, and close at top when full to hinder its evaporation; that these plants grow on the arms of the trees in the woods every where, [in those parts,] as also on the barks of their trunks. And one contrivance of Nature in this vegetable (he saith) is very admirable: the seed hath long and many threads of *tomentum*, not only that it may be carried every where by the wind, but also that it may by those threads, when driven through the boughs, be held fast, and stick to the arms and extant parts of the barks of trees. So soon as it sprouts or germinates, although it be on the under part of a bough, its leaves and stalk rise perpendicular, or straight up, because if it had any other position, the cistern (before-mentioned, by which it is chiefly nourished) made of the hollow leaves could not hold water, which is necessary for the nourishment and life of the plant. In scarcity of water, this reservoir is necessary and sufficient, not only for the plant itself, but likewise is very useful to men, birds, and all sorts of insects, whither they come in troops, and seldom go away without refreshment. *Id. ib.* p. 188. and *Phil. Transf.* No. 251, where a figure is of this notable plant, as also in *Lowthorp's Abridg.* vol. 2. p. 669. (See Pl. N, *fig.* 2.)

The *wild-pine*, so called, &c. hath leaves that will hold a pint and a half or a quart of rain-water; and this water refreshes the leaves and nourishes the root. When we find these pines, we stick our knives into the leaves, just above the root, and that lets out the water, which we catch in our hats, as I have done many times to my great relief. *Dampier's Voy. to Campeachy*, c. 2. p. 56.

vegetation and wants, but afford drink also both to man and other creatures in their great extremities (*dd*); and a great deal more might be instanced in of a like nature, and things that bear such

(*dd*) Navarette tells us of a tree called the *bejuco*, which twines about other trees, with its end hanging downwards; and that travellers cut the nib off it, and presently a spout of water runs out from it, as clear as crystal, enough, and to spare, for six or eight men. I drank (saith he) to my satisfaction of it, found it cool and sweet, and would drink it as often as I found it in my way. It is a juice and natural water. It is the common relief of the herdsmen on the mountains; when they are thirsty, they lay hold on the *bejuco* and drink their fill. *Collect. of Voy. and Trav. vol. 1. in the Suppl. to Navarette's Account of China, p. 355.*

The waterwith of *Jamaica* hath the same uses, concerning which my before-commended friend Dr. Sloane favoured me with this account from his original papers: *This vine growing on dry hills, in the woods where no water is to be met with, its trunk, if cut into pieces two or three yards long, and held by either end to the mouth, affords so plentifully a limpid, innocent, and refreshing water, or sap, as gives new life to the drouthy traveller or hunter. Whence this is very much celebrated by all the inhabitants of these islands, as an immediate gift of Providence to their distressed condition.*

To this we may add what Mr. Ray takes notice of concerning the birch-tree. *In initis veris antequam folia prodire, vulnerata dulcem succum copiosè effundit, quem siti pressi pastores in sylvis sæpenumerò potare solent. Nos etiam non semel eo liquore recreati sumus, cum herbarum gratiâ vastas peragravimus sylvas, inquit Tragus.*—"In the beginning of spring, before its leaves have come out, if the birch is wounded, it pours out most copiously a sweet juice which the shepherds often drink when thirsty. I myself, says Tragus, have been frequently refreshed with this liquor when I was wandering through vast forests in search of plants."—*Raii Cat. Plant. circa Cantab. in Betula.*

such plain inpresses of the Divine wisdom and care, that they manifest the superintendence of the Infinite Creator.

Thus I have given a sketch of another branch of the creation, which, (although one of the meanest, yet,) if it was accurately viewed, would abundantly manifest itself to be the work of God. But because I have been so long upon the other parts, although less than they deserve, I must therefore content myself with those general hints I have given; which may however serve as specimens of what might have been more largely said about this inferior part of the animated creation *.

As

* It may be no improper supplement to this chapter to exhibit a short view of the principal doctrines of that great naturalist Professor Linnæus, which are now almost universally adopted, and whose system, if true, as it has every appearance of being, certainly tends, in a very eminent degree, to the main purpose of this work,—the demonstration of the power, the consummate wisdom, and the benevolence of the great Creator of the universe.

The chief doctrines of Linnæus are, *1mo*, that vegetables are endowed with a certain degree of animal life; and *2do*, that they propagate their species in a manner similar to that of animals.

In support of his doctrine, that vegetables are endowed with life, he draws his arguments from the following particulars in their œconomy:

1. *Nutritio*.—The very idea of nutrition implies a propulsion of humours, and of course the idea of life.

2. *Ætas*.—Every animal must not only begin to exist, and have that existence terminated by death, but must likewise pass

As to the *inanimate part*, such as stones, minerals, earth, and such-like, that which I have already said in the beginning shall suffice.

through the intermediate stages of infancy, youth, manhood, old age, characterised by imbecility, beauty, fertility, and dotage. These vicissitudes are equally conspicuous in the vegetable world.

3. *Motus*.—Animals are capable of spontaneous motion: so are vegetables; witness the efforts of all plants to bend to the light; the shrinking of many plants from the touch, &c.

4. *Morbus*.—Vegetables are subject to diseases as well as animals.

5. *Mors*.—Like animals, all vegetables have a natural period of extinction from internal decay, and they are subject likewise to be cut off by various diseases proceeding from injury, improper nutriment, too much heat or cold, &c.

6. *Anatomia*.—The organic fibres, membranes, canals, vesicles, &c. of plants are additional proofs of their living powers.

7. *Organizatio*.—Vegetables not only propel humours, but also prepare and secrete different juices for the fruit, the nectar, gems, &c. analogous to the secretions of animal bodies.

From these facts and observations Linnæus concludes that plants are endowed with life as well as animals; and then proceeds to shew how these animated vegetables propagate their species.

After discussing the long exploded doctrine of equivocal generation, he lays hold of the maxim of Dr. Harvey, *Omne vivum ex ovo*. It being fully evident, says he, from the foregoing reasoning, that vegetables are endowed with life, it necessarily follows, agreeably to this maxim of Harvey's, that every vegetable must in like manner derive its existence from an egg; but as it is the distinguishing property of an egg to give birth to a being similar to that which produced it, the seeds must of course be the eggs of vegetables.

Granting then that the seeds of vegetables correspond to the eggs of animals, and considering that no egg can be fecundated
without

without receiving impregnation from the male, it follows that the seeds or eggs of vegetables cannot be fecundated by any other means. Hence also the necessity of vegetables being provided with organs of generation. But where are these organs situated? The answer is easy: we have already found impregnated seeds within the flowers of plants; and it is natural to expect that the *genitalia* should not be at a greater distance. Now as *copulation* always precedes *birth*, and every *flower* precedes the *fruit*, the *generating faculty* must be ascribed to the *flower*, and the *birth* to the *fruit*. Again, as the *antheræ* and *stigmata* are the only essential parts of flowers, these parts must necessarily be the *organs of generation*. Being thus far advanced, Linnaeus affirms that the *antheræ* are the *testes*, and that the *pollen* performs the office of the male *semen*, which he proves chiefly from their situation being such as to discharge the pollen with the greatest facility upon the *stigma* or female organ, from their always flourishing at the same time with the *stigmata*, and from the experiment of cutting off the *antheræ* from an hermaphrodite plant, in which case, if no other plant of the same species is near it, it will infallibly prove either abortive or produce barren seeds. From similar arguments he proves the *stigma* to be the female organ, adapted by Nature for the reception of the pollen or impregnating substance. The union of the sexes is accomplished by the conveyance of the pollen to the *stigma*, to which it adheres till it bursts, and discharges a subtile elastic fluid. This fluid, or *aura*, is absorbed by the vessels of the *stylus*, and carried directly to the *ovarium* or *germen*, where the mysterious work of impregnation is fully completed." On the whole, a most remarkable similitude obtains between the œconomy of Nature in the animal and vegetable kingdoms, both with respect to the changes that animals and plants undergo in the various stages of their existence, and in the mode by which they propagate their species; nor is the power and wisdom of the Creator less conspicuous in the one order of created substances, than it is in the other. "O Lord, how manifold are thy works! in wisdom hast thou made them all. The earth is full of thy riches." *Psalms* civ. v. 24.

As nothing so much facilitates the study of any science as a proper arrangement of the objects about which it is employed, it has been the endeavour of many naturalists to devise such an arrangement or classification as should embrace, in a small compass, all the characteristics that distinguish the different genera and species in the animal, vegetable, and mineral kingdoms. These arrangements have many advantages: they shew to the student of Nature the extent of his subject, and elevate his mind by the sense of its grandeur and importance; and they assist both his memory and his judgment in the prosecution of science. It is, however, to be regretted, with respect to most of these arrangements, that, being taken from those obvious and exterior marks which distinguish the different genera and species, they are of very little help to those who wish to study either their internal structure, or the uses and properties of the several objects of natural history. The only arrangement which seems to possess the latter advantage in any considerable degree, is the physiological table of M. D'Azyr, which, borrowing its several marks from internal characters, more clearly demonstrates the distinctions between the different objects of the mineral, vegetable, and animal kingdoms, than any system that attempts to arrange them by outward appearance. It is likewise in this respect extremely valuable that it contains, in a very small compass, an amazing fund of instruction in all the most important parts of the science of natural history, in so far as organized Nature is concerned. It cannot, therefore, be unacceptable to the reader to find here this most ingenious and useful table, as its purpose is so peculiarly connected with the scope and design of the present work. EDITOR.

M. D'AZYR'S TABLE OF THE FUNCTIONS OR PROPERTIES OF LIVING BODIES.

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3. CIRCULATION.	Living Bodies	with blood	Having a heart with two ventricles and two auricles,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			With one ventricle divided into several cavities and two auricles,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			With one ventricle and one auricle,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			Whose heart is formed of one longitudinal vessel, tuberosus and contractile, in which there is a whitish fluid instead of blood,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			In which no heart has been yet observed, but only vessels filled with juices of a nature different from that of blood,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
4. RESPIRATION.	Living Bodies	which respire	By lungs free from all adhesion, and spongy,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			By lungs free from all adhesion, vesicular and muscular,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			By lungs adhering to the ribs, and provided with appendages,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			By gills of different forms,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			By stigmata, or holes in different rings,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
5. SECRETION.	Living Bodies	By an opening called trachea, or by external fringes,	By an opening called trachea, or by external fringes,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
		By tracheae	By tracheae	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
			In which there have been discovered neither stigmata nor tracheae,	{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
				{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.
				{ Man. Quadrupeds. Cetaceous animals. Birds. Oviparous quadrupeds. Serpents. Cartilaginous fishes. Fishes, properly so called. Crustaceous animals. Insects. Worms. In some crustaceous animals there is observed something resembling a heart.

There are no bodies in which secretions are not carried on.

6.

Living Bodies

Internal and offshoots.

Internal and cartilaginous.

External and corneous.

External and cetaceous.

External and ligenous,

Which have no skeleton.

Viviparous.

Oviporous, whether the evolution of the eggs takes place within or without the female.

Which propagate by slips,

Man.

Quadrupeds.

Cetaceous animals.

Birds.

Oviparous quadrupeds.

Serpents.

Fishes, properly so called.

Cartilaginous fishes.

Perfect insects.

Lithophytes.

Cruftaceou

Shell-fish.

Madrepores.

The greatest part of Zoophytes.

Plants,

Infants in their first state.

Worms

Polypes.

Men. .

Quadrupeds.

Cetaceous animals.

Birds.

Oviparous quadrupeds.

Serpents. 72.

Cartilaginous fishes.

times, properly to called.

Subjects.

Crustaceous animals.

worms.

Plants.

Worms.

Polypes.
Plants

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M. D'AZYR'S TABLE OF THE FUNCTIONS OR PROPERTIES OF LIVING BODIES.

Greatest part of insects in the first state of their transformation.

A body muscular or contractile

IRRITABILITY.

Living Bodies

which have

Muscles covering the skeleton,

A skeleton covering the muscles,

No muscular power, no spontaneous movements,

Living Bodies

which have

Nerves and brain easily distinguishable from the spinal marrow,

Nerves and brain scarcely distinguishable from the spinal marrow,

In which there have not yet been discovered nerves, brain, or spinal marrow,

SENSIBILITY.

Worms.

Polypes.

Man.

Quadrupeds.

Cetaceous animals.

Birds.

Oviparous quadrupeds.

Serpents.

Cartilaginous fishes.

Fishes, properly so called.

Perfect insects.

Crustaceous animals.

Plants.

Man.

Quadrupeds.

Cetaceous animals.

Birds.

Oviparous quadrupeds.

Serpents.

Cartilaginous fishes.

Fishes, properly so called.

Insects.

Crustaceous animals.

Worms.

Zoophytes.

Plants.

B O O K XI.

Practical Inferences from the foregoing
Survey.

HAVING in the preceding Books carried my survey as far as I care at present to engage myself, all that remaineth, is to draw some inferences from the foregoing scene of the great Creator's works, and so conclude this part of my intended work.

C H A P. I.

That God's Works are great and excellent.

THE first inference I shall make, shall be by way of confirmation of the text, that *the works of the Lord are great* (a). And this is necessary to be observed, not against the atheist only, but all other careless incurious observers of God's works. Many of our useful labours, and some of our best modern books shall be condemned with only this note of reproach, that they are about trivial matters (b), when in truth they are ingenious and noble discoveries of the works of God. And how often

(a) *Equidem ne laudare quidem satis pro merito possum ejus sapientiam ac potentiam, qui animalia fabricatus est. Nam ejusmodi opera non laudibus modò, verùm etiam hymnis sunt majora, quæ priusquam inspexissemus, fieri non posse persuasum habeamus, conspicati verò, falsos nos opinione fuisse comperimus.*—"For I can never enough admire and praise his almighty power and wisdom who framed the animal creation. His works indeed surpass the praise of men, and even hymns are unequal to the expression of his mighty operations which, antecedent to our knowledge of them, we must have concluded to be beyond all power, and utterly impossible; but when we come to know them, we then perceive we have formed a very inadequate opinion of his attributes."—*Galen de Uf. Part. I. 7. c. 15.*

(b) *Non tamen pigere debet lectores, ea intelligere, quemadmodum ne Naturam quidem piguit ea reipsà efficere.*—"For we ought never to despise the knowledge of those things as mean and frivolous, which Nature herself did not disdain to form."—*Galen. ibid. l. II. fin.*

often will many own the world in general to be a manifestation of the infinite Creator, but look upon the several parts thereof as only toys and trifles, scarce deserving their regard? But in the foregoing (I may call it) transient view I have given of this lower and most slighted part of the creation, I have, I hope, abundantly made out, that all the works of the Lord, from the most regarded, admired, and praised, to the meanest and most slighted, are great and glorious works, incomparably contrived, and as admirably made, fitted up, and placed in the world. So far then are any of the works of the Lord (even those esteemed the meanest) from deserving to be disregarded, or contemned by us (*c*), that on the contrary they deserve (as shall be shewn in the next chapter) to be *sought out, inquired after, and curiously and diligently pryed into* by us; as I have shewed the word in the text implies.

(*c*) *An igitur etiam si quemadmodum Natura hæc, & ejusmodi, summâ ratione ac providentiâ agere potuit, ita & nos imitari aliquando possemus? Ego verò existimo multis nostrum ne id quidem posse, neque enim artem Naturæ exponunt: Eo enim modo omnino eam admirarentur, sin minus, eam saltem non vituperarent.* — “But as Nature has framed all these things with admirable wisdom and foresight, could we not ourselves imitate her in some of her operations? I fear it is hardly possible for us; considering we do not even give ourselves the trouble of explaining the artifice of Nature. If we did so, we should either give her the due tribute of our praise, or at least cease to blame and cavil at her works.” — *Galen. de Us. Part. l. 10. c. 3.*

CHAP. II.

That God's Works ought to be inquired into, and that such Inquiries are commendable.

THE *Creator* doubtless did not bestow so much curiosity, and exquisite workmanship and skill upon his creatures, to be looked upon with a careless, incurious eye, especially to have them slighted or contemned; but to be admired by the rational part of the world, to magnify his own power, wisdom, and goodness throughout all the world, and the ages thereof: and therefore we may look upon it as a great error not to answer those ends of the infinite *Creator*, but rather to oppose and affront them. On the contrary, my text commends God's works, not only for being great, but also approves of those curious and ingenious inquirers, that *seek them out, or pry into them*. And the more we pry into and discover of them, the greater and more glorious we find them to be, the more worthy of, and the more expressly to proclaim their great *Creator*.

Commendable then are the researches, which many amongst us have, of late years, made into the works of Nature, more than hath been done in some ages before. And therefore when we are asked, *Cui bono?* To what purpose such inquiries, such pains, such expence? the answer is easy, it
is

is to answer the ends for which God bestowed so much art, wisdom, and power about them, as well as given us senses to view and survey them, and an understanding and curiosity to search into them: It is to follow and trace him, when and whither he leads us, that we may see and admire his handy-work ourselves, and set it forth to others, that they may see, admire, and praise it also. I shall then conclude this inference with what *Elibu* recommends, *Job. xxxvi. 24, 25. Remember that thou magnify his work, which men behold. Every man may see it, men may behold it afar off.*

C H A P. III.

*That God's Works are manifest to all: whence the
Unreasonableness of Infidelity.*

THE concluding words of the preceding chapter suggests a third inference, that the works of God are so visible to all the world, and withal such manifest indications of the being, and attributes of the infinite Creator, that they plainly argue the vileness and perverseness of the atheist, and leave him inexcusable. For it is a sign a man is a wilful, perverse atheist, that will impute so glorious a work, as the creation is, to any thing, yea, a mere *nothing*, (as chance is,) rather than to God (a).
It

(a) *Galen* having taken notice of the neat distribution of the nerves to the muscles, and other parts of the face, cries out, *Hec enim fortune sunt opera! Ceterum tum omnibus [partibus] immitti, tantosque esse singulos [nervos] magnitudine, quanta particula erat necesse; haud scio an hominum sit sobriorum ad fortunam opificem id revocare. Alioqui quid tandem erit, quod cum providentiâ & arte efficitur? Omnino enim hoc ei contrarium esse debet, quod casu ac fortuito fit.*—“Are these forsooth the operations of chance? When we observe the insertion of the nerves in the several parts of the body, and their proportionate magnitude to the part in which they are inserted, can any man in his sober judgment refer that to the operation of chance? If so, what is there else that is the result of foresight and of art? For it must be in its nature contrary to that which is effected by chance.”—And
afterwards,

It is a sign the man is wilfully blind, that he is under the power of the devil, under the government of prejudice, lust, and passion, not right reason, that will not discern what *every one can see, what every man may behold afar off*, even the existence and attributes of the Creator from his works. For as *there is no speech or language where their voice is not heard, their line is gone out through all the earth, and their words to the end of the world*: so all, even the barbarous nations, that never heard of God, have from these his works inferred the existence of a Deity, and paid their homages to some deity, although they have been under great mistakes in their notions and conclusions about him. But however, this shews how naturally and universally all mankind agree, in deducing their belief of a God from the contemplation of his works, or as even *Epicurus* himself, in *Tully* (b), saith, from a
notion

afterwards, *Hæc quidem atque ejusmodi artis scil. ac sapientiæ opera esse dicemus, si modò fortune tribuenda sunt quæ sunt contraria; fietque jam quod in proverbis—Fluvii sursum fluent; si opera quæ nullum habent neque ornamentum, neque rationem, neque modum artis esse; contraria verò fortune duxerimus, &c.*—"For every thing that is wild and irregular we must then attribute to art and wisdom, if we esteem its contrary to be the result of chance; and thus in the words of the Proverbs, the rivers will run backwards to their source, if we hold every thing in which we perceive neither reason nor beauty to be the result of skill, and every thing possessed of those qualities to be the effect of chance."—*Galen ubi supra, l. 11. c. 7.*

(b) *Primum esse Deos, quod in omnium animis, &c.* And a little after, *Cùm enim non instituto aliquo, aut more, aut lege sit opinio constituta,*

notion that Nature itself hath imprinted upon the minds of men. For, saith he, what nation is there, or what kind of men, that without any teaching or instructions, have not a kind of anticipation or pre-conceived notion of a deity?

An atheist therefore (if ever there was any such) may justly be esteemed a monster among rational beings; a thing hard to be met with in the whole tribe of mankind; an opposer of all the world (c); a rebel against human nature and reason, as well as against his God.

But above all monstrous is this, or would be in such as have heard of God, who have had the benefit of the clear gospel revelation. And still more monstrous this would be, in one born and baptized in the Christian church, that hath studied Nature, and

stituta, maneatque ad unum omnium firma consensus, intelligi necesse est, esse Deos, quoniam insitas eorum vel potius innatas cognitiones habemus. De quo autem omnium natura consentit, id verum esse necesse est. Esse igitur Deos confitendum est.—"For as that opinion is neither the effect of education, of custom, nor of human laws, but is firmly rooted in the consent of all mankind, we must thence of necessity conclude that there is a God, from that innate opinion of the mind. That in which all mankind consents must be a truth. We must then confess there is a God."—*Cicer. de Nat. Deor.* A. I. c. 16, 17.

(c) The atheist in denying a God, doth, as *Plutarch* saith, endeavour—*immobilia movere, & bellum inferre non tantum longo tempori, sed & multis hominibus, gentibus, & familiis, quas religiosus Deorum cultus, quasi divino furore correptas, tenuit.*—"To move what is immoveable, and to wage war, not only with time, but with all nations, kindreds, and families, who with fervent zeal have paid religious worship to the Divinity."—*Plutar. de Iside.*

and pried farther than others into God's works. For such an one (if it be possible for such to be) to deny the existence or any of the attributes of God, would be a great argument of the infinite inconvenience of those sins of intemperance, lust, and riot, that have made the man abandon his reason, his senses, yea, I had almost said his very human nature (*d*), to engage him thus to deny the being of God.

So also it is much the same monstrous infidelity, at least it betrays the same atheistical mind, to deny God's providence, care, and government of the world, or (which is a spawn of the same *Epicurean principles*) to deny *Final Causes* (*e*) in God's works of creation; or with the profane, in *Psal. lxxiii. 11.* to say, *How doth God know? and is there knowledge in the most High?* For as the witty and eloquent *Salvian* saith (*f*), *They that affirm nothing is seen by God, will, in all probability, take away the substance*

(*d*) See before, note (*b*).

(*e*) *Galen*, having substantially refuted the *Epicurean* principles of *Asclepiades*, by shewing his ignorance in anatomy and philosophy, and by demonstrating all the *causes* to be evidently in the works of nature, viz. *final, efficient, instrumental, material, and formal causes*, concludes thus against his fortuitous atoms, *ex quibus intelligi potest: conditorem nostrum in formandis particulis unum hunc sequi scopum, nempe ut quod melius est eligat.*—"Whence we may conclude that our great Creator, in the formation of bodies, has invariably followed this one rule, always to choose what is best."—*Galen de Us. Part. l. 6. c. 13.*

(*f*) *De Gubern. Dei, l. 4. p. 124. meo Libro; also l. 7. c. 14.*

stance as well as sight of God.—But what so great madness, saith he, as that when a man doth not deny God to be the creator of all things, he should deny him to be the governor of them? or when he confesseth him to be the maker, he should say, God neglecteth what he hath so made?*

* See a discussion of the utility of the research into *Final Causes*, in the Preliminary Account of the Life and Writings of Mr. Derham, p. xl.

CHAP. IV.

*That God's Works ought to excite us to Fear and
Obedience to God.*

SINCE the works of the creation are all of them so many demonstrations of the infinite wisdom and power of God, they may serve to us as so many arguments exciting us to the constant *fear of God*, and to a steady, hearty *obedience* to all his laws. And thus we may make these works as serviceable to our spiritual interest, as they all are to our life and temporal interest. For if whenever we see them, we would consider that these are the works of our infinite *Lord and Master*, to whom we are to be accountable for all our thoughts, words, and works, and that in these we may see his infinite power and wisdom; this would check us in sinning, and excite us to serve and please Him who is above all control, and who hath our life and whole happiness in his power. After this manner God himself argues with his own *foolish people, and without understanding, who had eyes, and saw not, and had ears, and heard not*, Jer. v. 21, 22. *Fear ye not me? saith the Lord: will ye not tremble at my presence, which have placed the sand for the bound of the sea, by a perpetual decree that it cannot pass it; and though the waves thereof toss*
VOL. II. D D *them-*

themselves, yet can they not prevail; though they roar, yet can they not pass over it?

This was an argument that the most ignorant, stupid wretches could not but apprehend; that a Being, that had so vast and unruly an element as the sea absolutely at his command, ought to be feared and obeyed; and that he ought to be considered as the sovereign Lord of the world, on whom the world's prosperity and happiness did wholly depend; ver. 24. *Neither say they in their heart, let us now fear the Lord our God, that giveth rain, both the former and the latter in his season: he reserveth unto us the appointed weeks of the harvest.*

CHAP. V.

That God's Works ought to excite us to Thankfulness.

AS the demonstrations which God hath given of his infinite *power* and *wisdom* should excite us to fear and obedience; so I shall shew in this chapter, that the demonstrations which he hath given of his infinite *goodness* in his works, may excite us to due thankfulness and praise. It appears throughout the foregoing survey, what kindness God hath shewn to his creatures in providing every thing conducing to their life, prosperity, and happiness (a); how they are all contrived and made in the

(a) *Si pauca quis tibi donasset jugera, accepisse te diceres beneficium: immensa terrarum latè patentium spatia negas esse beneficium? Si pecuniam tibi aliquis donaverit—beneficium vocabis: tot metalla defodit, tot flumina emisit in aëra, super quæ decurrunt sola aurum vebentia: argenti, æris, ferri immane pondus omnibus locis obrutum, cujus investigandi tibi facultatem dedit,—negas te accepisse beneficium? Si domus tibi donetur, in quâ marmoris aliquid resplendeat, &c. num mediocre munus vocabis? Ingens tibi domicilium, sine ullo incendii, aut ruinae metu struxit, in quo vides non tenues crustas—sed integras lapidis pretiosissimi moles, &c. negas te ullum munus accepisse? Et cum ista quæ habes magno aestimes, quod est ingrati hominis, nulli debere te judicas? Unde tibi istum quem trabis spiritum? Unde istam, per quam ductus vite tuæ disponis atque ordinas, lucem? &c.—“ If any one had made you a present of a few acres of land, you*

the best manner, placed in the fittest places of the world for their habitation and comfort; accoutred in the best manner, and accommodated with every, even all the minutest things that may minister to their health, happiness, office, occasions, and business in the world.

Upon which account, thankfulness and praise is so reasonable, so just a debt to the *Creator*, that the *Psalmist* calleth upon all the creatures to praise God, in *Psalms* cxlviii. *Praise him all his angels, praise him all his hosts; sun, moon, stars of light, heavens of heavens, and waters above the heavens.* The reason given for which is, ver. 5, 6. *For he commanded, and they were created; he hath also established them for ever and ever; he hath made a decree which they shall not pass.* And not these celestials

would own he had conferred a benefit on you. Do you then deny that the immense expanse of land which this universe contains is a benefit? If any one had given you a sum of money, you would call it a benefit. Yet Providence has formed the mines, the rivers which wash down the precious ores with their sands, the stores of silver and of brass which the earth conceals, and of which the use is free to man; and shall he deny that these are benefits? If any one should give you a house in which there are a few marble decorations, will you term it a small present? Providence has built for you a boundless habitation, which is in no danger of fire or of decay, and has furnished it not with little fragments, but with immeasurable masses of those precious stones; and shall you count that no benefit? Or if you value at a great price those possessions which you enjoy, do you, ungrateful man! owe no debt to him who gave them? To whom do you owe that spirit which you breathe, that light which guides you in all your works and undertakings?"—*Senec. de Benef.* l. 4. c. 6.

tials alone, but the creatures of the earth and waters too, even the meteors, *fire and hail, snow and vapours, stormy winds fulfilling his word.* Yea, the very mountains and hills, trees, beasts, and all cattle, *creeping things, and flying fowl.* But in a particular manner, all the ranks and orders, all the ages and sexes of mankind are charged with this duty; *Let them praise the name of the Lord, for his name alone is excellent; his glory is above the earth and heavens;* ver. 13.

And great reason there is we should be excited to true and unfeigned thankfulness and praise (b)
to

(b) *Tempestivum tibi jam fuerit, qui in hisce libris versaris considerare, in utram familiam recipi malis, Platoniamne ac Hippocraticam, & aliorum virorum, qui Naturæ opera mirantur; an eorum qui ea insectantur, quod non per pedes Natura constituit effluere excrementa.*—"It would now be proper for you who have been employed in the study of these books to consider with yourselves with what family or society you choose to rank; whether with that of Plato, Hippocrates, and those other illustrious men who have been admirers of the works of Nature, or with those others who find fault with Nature for not contriving us so that the excrement should be voided by the feet."—Of which having told a story of an acquaintance of his that blamed Nature on this account, he then goes on, *At verò si de hujusmodi pecudibus plura verba fecero, melioris mentis homines meritò mihi forte succenseant, dicantque me polluere sacrum sermonem, quem ego Conditoris nostri verum hymnum compono, existimoque in eo veram esse pietatem,—ut si noverim ipse primus, deinde & aliis exposuerim, quenam sit ipsius sapientia, quæ virtus, quæ bonitas. Quod enim cultu conveniente exornaverit omnia, nullique bona inviderit, id perfectissimæ bonitatis specimen esse statuo; & hac quidem ratione ejus bonitas hymnis nobis est celebranda. Hoc autem omne invenisse quo pacto omnia potissimum adornarentur, summæ sapientiæ est: effecisse autem omnia, quæ voluit,*

to this our great benefactor, if we reflect upon what hath been shewn in the preceding survey, that the *Creator* hath done for man alone, without any regard to the rest of the creatures, which some have held were made for the sake of man. Let us but reflect upon the excellence and immortality of our soul; the incomparable contrivance and curious structure of our body; and the care and caution taken for the security and happiness of our state, and we shall find, that among the whole race of beings, man hath especial reason to magnify the Creator's goodness, and with suitable ardent affections to be thankful unto him.

virtutis est invidiæ.—" But if I should waste more words on such stupid animals, I should incur the displeasure of all men of better understanding, who would declare that I had polluted that holy discourse which I have been employed in composing to my Maker's honour, and as the best hymn to his praise: the fruit of my knowledge which I have endeavoured to impart to others, and to teach them what is wisdom, what is virtue, what is goodness. For I hold that to be the proof of his most perfect goodness, that He has given to every thing those qualities which are most suitable to its nature, and to every order of beings its peculiar advantages. To discern what qualities were most suitable, is the proof of the highest wisdom, as to frame all according to his will, is of the highest power."—*Galen de Us. Part. l. 3. c. 10.*

C H A P. VI.

That we ought to pay God all due Homage and Worship, particularly that of the Lord's Day.

FOR a conclusion of these lectures, the last thing I shall infer, from the foregoing demonstration of the being and attributes of God, shall be, that we ought to pay God all that *homage* and *worship* which his right of creation and dominion entitle him unto, and his great mercies call for from us. And forasmuch as the *Creator* appointed, from the very creation, one day in seven to his service, it will not therefore be improper to say something upon that subject: and if I insist somewhat particularly and largely thereon, the congruity thereof to the design of these lectures and the foregoing demonstration, together with the too great inadvertency about and neglect of this ancient, universal, and most reasonable and necessary duty, will, I hope, plead my excuse. But that I may say no more than is necessary on this point, I shall confine myself to two things; the *time* God hath taken, and the *business* then to be performed.

I. The *time* is one day in seven, and one of the most ancient appointments it is which God gave to the world. For as soon as God had finished his *six* days works of creation, it is said, *Gen. ii. 2, 3.*

He rested on the seventh day from all his work which he had made. And God blessed the seventh day, and sanctified it, because that in it he had rested from all his work. This sanctification (a) and blessing the seventh day was setting it apart, as a day of distinction from the rest of the week-days, and appropriating it to holy uses and purposes, namely, the commemoration of that great work of the creation, and paying homage and worship to that infinite Being who was the effecter of it.

This day, thus consecrated from the beginning, for the celebration of the τῇ κόσμῳ γενέσθιον, the *world's birth-day*, as *Philo* calls it, was probably in some measure forgotten in the following wicked ages, which God complains of, *Gen. vi. 5.* and so after the flood likewise. But after the return out of *Egypt*, when God settled the *Jewish* polity, he was pleased to renew this day, and to establish it for a perpetual standing law. And accordingly it was observed down to our blessed Saviour's time, countenanced, and strictly observed by our great Lord and Master himself, and his apostles and disciples in and after his time; and although for good reasons the day was changed by them, yet a seventh day had been constantly observed in all ages of Christianity down to our present time.

Thus

(a) שֶׁבַע *Usibus divinis accommodavit, à communi & profano usu segregavit, in usum sacrum ad cultum Dei destinavit.*—"Accommodated to divine uses, separated from what is common and profane, and destined for the worship of God."—*Kirch. Concord.* p. 1336. *Destinari ad aliquid, sacrari, &c.* Buxtorf. in Verbo.

Thus we have a day appointed by God himself, and observed throughout all ages, except some few perhaps, which deserve not to be brought into example.

And a wise designation of time this is, well becoming the Divine care and precaution; serving for the recruiting our bodies and dispatching our affairs, and at the same time to keep up a spiritual temper of mind. For by allowing six days to labour, the poor hath time to earn his bread, the man of business time to dispatch his affairs, and every man time for the work of his respective calling. But had there been more, or all our time allotted to labour and business, and none to rest and recruit, our bodies and spirits would have been too much fatigued and wasted, and our minds have been too long engaged about worldly matters, so as to have forgotten divine things. But the infinitely wise Ruler of the world, having taken the seventh part of our time to his own service, hath prevented these inconveniences; hath given a relaxation to ourselves, and ease and refreshment to our wearied beasts, to poor fatigued slaves, and such as are under the bondage of avaricious, cruel masters. And this is one reason *Moses* gives of the reservation and rest on the seventh day. *Deut. v. 13, 14, 15. Six days shalt thou labour, and do all thy work; but the seventh is the sabbath of the Lord thy God; in it thou shalt not do any work, thou, nor thy children, servants, cattle, or stranger, that thy man-servant and maid servant may rest as well as thou. And re-*
member.

member, that thou wast a servant, &c. therefore the Lord thy God commanded thee to keep the sabbath day. That carnal, greedy people, so bent upon gain, without such a precept, would have scarce favoured their own bodies, much less have had mercy upon their poor bondsmen and beasts; but by this wise provision, this great burden was taken off. But on the other hand, as a longer liberty would too much have robbed the master's time, and bred idleness, so by this wise provision, of only one day of rest to six of labour, that inconvenience was also prevented.

Thus the wise Governor of the world hath taken care for the dispatch of business. But then, as too long engagement about worldly matters, would take off men's minds from God and divine matters, so, by this reservation of every seventh day, that great inconvenience is prevented also; all being then bound to worship their great Lord and Master, to pay their homages and acknowledgments to their infinitely kind benefactor; and, in a word, to exercise themselves in divine, religious business, and so keep up that spiritual temper of mind, that a perpetual or too long application to the world would destroy.

This, as it was a good reason for the order of a sabbath to the *Jews*, so is as good a reason for our Saviour's continuance of the like time in the Christian church.

And a law this is, becoming the infinitely wise Creator and Conservator of the world; a law not

only of great use to the perpetuating the remembrance of those greatest of God's mercies then commemorated, but also exactly adapted to the life, occasions, and state of man; of man living in this, and a-kin to another world: a law well calculated to the dispatch of our affairs, without hurting our bodies or minds. And since the law is so wise and good, we have great reason then to practise carefully the duties incumbent upon us; which will fall under the consideration of the

II^d Thing I proposed; the *business* of the day, which God hath reserved to himself. And there are two things enjoined in the commandment, a *cessation* from labour and worldly business; and that we *remember to keep* the day holy.

1. There must be a cessation from worldly business, or a rest from labour, as the word *sabbath* (*b*) signifies. *Six days thou shalt do all thy work, but the seventh is the sabbath of the Lord thy God, (not thy day but his,) in which neither thou, nor any belonging to thee, shall do any work.* - In which injunction it is observable, how express and particular this commandment is, more than others, in ordering all sorts of persons to cease from work.

2. We must *remember to keep the day holy*. Which remembrance is another thing also in this, more than in the other commandments, and implies,

1st, That there is great danger of our forgetting, neglecting, or being hindered from keeping the day holy, either by the infirmity and carnality of

(*b*) שבת *Cessatio, requies.*—"Rest."

of our own nature, or from the avocations of the world.

2dly, That the keeping it holy, is a duty of more than ordinary consequence and necessity. And of greatest consequence this is,

First, To perpetuate the remembrance of those grand works of God commemorated on that day; in the first ages of the world, the creation; in the middle ages, the creation and delivery from *Egypt*; and under Christianity, the creation and redemption by Christ. Which mercies, without such frequent occasions, would be ready to be forgotten or disregarded in so long a tract of time as the world hath already stood, and may by God's mercy still stand.

Secondly, To keep up a spiritual temper of mind by those frequent weekly exercises of religion as hath been already mentioned.

Thirdly, To procure God's blessing upon the labours and business of our six days, which we can never expect should be prosperous, if we are negligent of God's time. For how can we expect God's blessing upon a week so ill begun, with a neglect, or abuse of God's first day? and therefore if we become unprosperous in the world; if losses, troubles, or dangers befall us, let us reflect how we have spent the *Lord's* day; whether we have not wholly neglected it, or abused it in riot, or made it a day for taking journies, for more private business, and less scandalous labour, as the custom of too many is.

Thus

Thus having shewn what reason there is to *remember* to keep holy the day dedicated to God, I shall consider how we are to keep it holy, and so conclude. Now the way to keep it holy, is not by bare resting from work; for that, as a father saith, is *sabbatum boum & asinorum*, a *sabbath of beasts*: but holy acts are the proper business for a holy day, celebrated by rational beings. Among all which, the grand, principal, and most universally practised, is the *public worship of God*, the assembling at the *public place of his worship*, to pay (with our fellow creatures) our homages, thanks, and praises to the infinite *Creator and Redeemer* of the world. This, as it is the most reasonable service and proper business for this day, so is what hath been the practice of all ages. It was as early as *Cain and Abel's days*, *Gen. iv. 3.* what was practised by religious persons in the following ages, till the giving of the law; and at the giving of that, God was pleased to order places, and his particular worship, as well as the seventh day. The tabernacle and temple were appointed by God's express command; besides which, there were synagogues all over the nation; so that in our Saviour's time, every great town or village had one or more in it, and *Jerusalem* 460, or more (c).

The worship of these places, our blessed Saviour was a constant and diligent frequenter of. It is said, *He went about all the cities and villages, teaching in their synagogues, and preaching, and healing,*
 &c.

(c) See *Lightfoot's works*, vol. ii. p. 35, and 646.

&c. *Mat. ix. 35.* And *St. Luke* reporteth it as his constant custom or practice, *Luke iv. 16.* And as his custom was, he went into the synagogue on the sabbath-day.

Having thus mentioned the practice of Christ, it is not necessary I should say much of the practice of his apostles, and the following purer ages of christianity, who, in short, as their duty was, diligently followed their great Master's example. *They did not think it enough to read and pray, and praise God at home, but made conscience of appearing, in the public assemblies, from which nothing but sickness and absolute necessity did detain them; and if sick, or in prison, or under banishment, nothing troubled them more than that they could not come to church, and join their devotions to the common services. If persecution at any time forced them to keep concealed; yet no sooner was there the least mitigation, but they presently returned to their open duty, and publicly met all together. No trivial pretences, no light excuses were then admitted for any one's absence from the congregation, but according to the merit of the cause, severe censures were passed upon them, &c.* to express it in the words of one of our best antiquaries (*d*).

The public worship of God then is not a matter of indifference, which men have in their own power to do or omit as they please; neither is it enough to read, pray, or praise God at home (unless some inevitable necessity hindereth); because the

(*d*) *Dr. Cave's Primitive Christianity, par. i. cap. 7.*

appearing in God's house on *his* day is an act of *homage* and *fealty* due to the Creator, a *right of sovereignty* we pay him. And the withholding those rights and dues from God, is a kind of rejecting God, a disowning his sovereignty, and a withdrawing our obedience and service. And this was the very reason why the profanation of the sabbath was punished with death among the *Jews*, the sabbath being a sign or badge of the God they owned and worshipped (*e*). Thus *Exod.* xxxi. 13. *My sabbaths*

(*e*) At this day it is customary for servants to wear the livery of their masters, and others to bear badges of their order, profession, servility, &c. So in former ages, and divers countries, it was usual to bear badges, marks, and signs on divers occasions. In *Ezek.* ix. 4. *A mark was to be set on the forehead of those that lamented the abominations of the city.* The like was to be done upon them in *Rev.* vii. 3. and ix. 4. So the worshippers of the Beast, *Rev.* xiii. 16. were to receive a *χάραγμα*, a mark in their right hand, on their foreheads. Those *χαράγματα*, *Σφραγίδες*, badges, &c. were very common. Soldiers and slaves bear them in their arms or foreheads; such as were matriculated in the *heterie*, or companies, bear the badge or mark of their company; and whoever lifted himself into the society of any of the several gods, received a *χάραγμα*, or a mark in his body, (commonly made with red-hot needles, or some burning in the flesh,) of the god he had lifted himself under. And after Christianity was planted, the Christians had also their *sign of the cross*. And not only marks in their flesh, badges on their clothes, &c. were usual; but also the dedication of days to their imaginary deities. Not to speak of their festivals, &c. the days of the week were all dedicated to some of their deities. Among the *Romans*, Sunday and Monday, to the *Sun* and *Moon*; Tuesday, to *Mars*; Wednesday, to *Mercury*, &c. So our *Saxon* ancestors did the same; Sunday and Monday, (as the *Romans* did,) to the *Sun* and *Moon*; Tuesday, to *Tuysco*; Wednesday, to *Woden*;

baths ye shall keep ; for it is a sign between me and you, throughout your generations, that ye may know that I am the Lord, that doth sanctify you ; or as the original may be rendered, A sign to acknowledge, that I Jehovah am your sanctifier, or your God : for as our learned Mede observes, To be the sanctifier of a people, and to be their God, is all one. So likewise very expressly in Ezek. xx. 20. Hallow my sabbaths, and they shall be a sign between me and you, that ye may know that I am the Lord your God ; or rather as before, to acknowledge that I Jehovah am your God.

The sabbath being thus a sign, a mark, or badge, to acknowledge God to be their God, it follows, that a neglect or contempt of that day redounded to God ; to slight that, was slighting God ; to profane that, was to affront God ; for the punishment of which, what more equitable penalty than death ? And although, under Christianity, the punishment is not made capital, yet have we no less reason for the strict observance of this holy day, than the *Jews*, but rather greater reasons. For the God we worship is the same : If after six days labour, He was, by the seventh, owned to be God, the *Creator* ; no less is He by our Christian Lord's day : if by the celebration of the sabbath, the remembrance of their deliverance from the *Egyptian* bondage was kept up,

Woden ; Thursday, to Thor ; Friday, to Friga ; and Saturday, to Seater : an account of which deities, with the figures under which they were worshipped, may be met with in our learned Vershegan, chap. 3. p. 68.

up, and God acknowledged to be the effector thereof; we Christians have a greater deliverance, we own our deliverance from sin and Satan, wrought by a greater Redeemer than *Moses*, even the blessed Jesus, whose resurrection, and the completion of our redemption thereby, was performed on the Christian Lord's day.

And now to sum up, and conclude these inferences, and so put an end to this part of my survey: since it appears, that the works of the Lord are so great, so wisely contrived, so accurately made, as to deserve to be inquired into; since they are also so manifest demonstrations of the Creator's being and attributes, that all the world is sensible thereof, to the great reproach of atheism: what remaineth? but that we fear and obey so great and tremendous a Being; that we be truly thankful for, and magnify and praise his infinite mercy, manifested to us in his works. And forasmuch as he hath appointed a day on purpose, from the beginning, for these services, that we may weekly meet together, commemorate and celebrate the great work of creation; that we may pay our acts of devotion, worship, homage and fealty to him; and since this is a wise and excellent distribution of our time, what should we do, but conscientiously and faithfully pay God these his rights and dues? And as carefully and diligently manage God's time and discharge his business then, as we do our own upon our six days; particularly that with the pious *Psalmist*, *We love*

the habitation of God's house, and the place where his honour dwelleth; and therefore take up his good resolution in Psal. ver. 7. with which I shall conclude; But as for me, I will come into thine house in the multitude of thy mercy, and in thy fear will I worship towards thy holy temple.

Now to the same infinite God, the omnipotent Creator and Preserver of the world, the most gracious Redeemer, Sanctifier, and Inspirer of mankind, be all honour, praise, and thanks, now and ever. *Amen.*

APPENDIX

TO

BOOK IV.—CHAP. X.

A TABLE of the Duration of Life in certain Animals.

	Years.
THE Elephant from	150 to 200
The Camel from	50 to 60
The Ass from	25 to 50
The Horse from	25 to 30
The Deer	20
The Ox employed in agriculture	19
The Bull	30
The Cow sometimes more than	20
The Lion	60
The Fox	15
The Bear	20
The Wolf	20
The Dog from	23 to 28
The Hare from	7 to 8
The Squirrel	7
The Cat	18
The Hog	20
The Sheep	10
The Goat	10
The Rabbit from	8 to 9

	Years.
The Eagle - - - - -	100
The Swan - - - - -	100
The Goose - - - - -	50
The Peacock - - - - -	24
The Sparrow-hawk - - - - -	40
The Canary, if it does not couple	24
----- if it breeds annually	10
The Nightingale and Lark from	16 to 18
The Hen - - - - -	10
The Tortoise - - - - -	100
The Crocodile - - - - -	100
The Pike sometimes more than	40
The Carp from - - - - -	100 to 150
The River Cray-fish - - - - -	20
The Scorpion - - - - -	1
The Spider - - - - -	1

*Supplemental Remarks to those contained in the same Chapter
on the Duration of Life and on Population.*

Supposing the earth peopled with 100,000,000 inhabitants, and allowing 33 years for a generation, it has been computed that the deaths of each year amount to

Of each year to	30,000,000
Of each day to	82,135
Of each hour to	3,442 $\frac{1}{2}$

But as the number of deaths to the number of births is (according to the more-recent computations) as 10 to 12, there are born every year

Every day	98,000
Every hour	4,107 $\frac{1}{2}$

Reckoning only three generations to a century, and supposing at the same time that the world has only existed 5700 years, there have been only 171 generations from the creation to the present time; 124 since the deluge, and 53 since the Christian era.

On an equal space, where there exists

In Iceland	-	-	-	1 Man,
There is in Norway	-	-	-	3
Sweden	-	-	-	14
Turkey	-	-	-	36
Poland	-	-	-	52
Spain	-	-	-	63
Ireland	-	-	-	99
Switzerland	-	-	-	114
G. Britain	-	-	-	119
Germany	-	-	-	127
France	-	-	-	158
Italy,	-	-	-	162
Naples	-	-	-	192
Venice	-	-	-	196
Holland	-	-	-	224
Malta	-	-	-	1103

Out of every thousand men 28 die annually.

The number of inhabitants of a city or country is renewed nearly every thirty years.

Of 200 children no more than one dies in the birth.

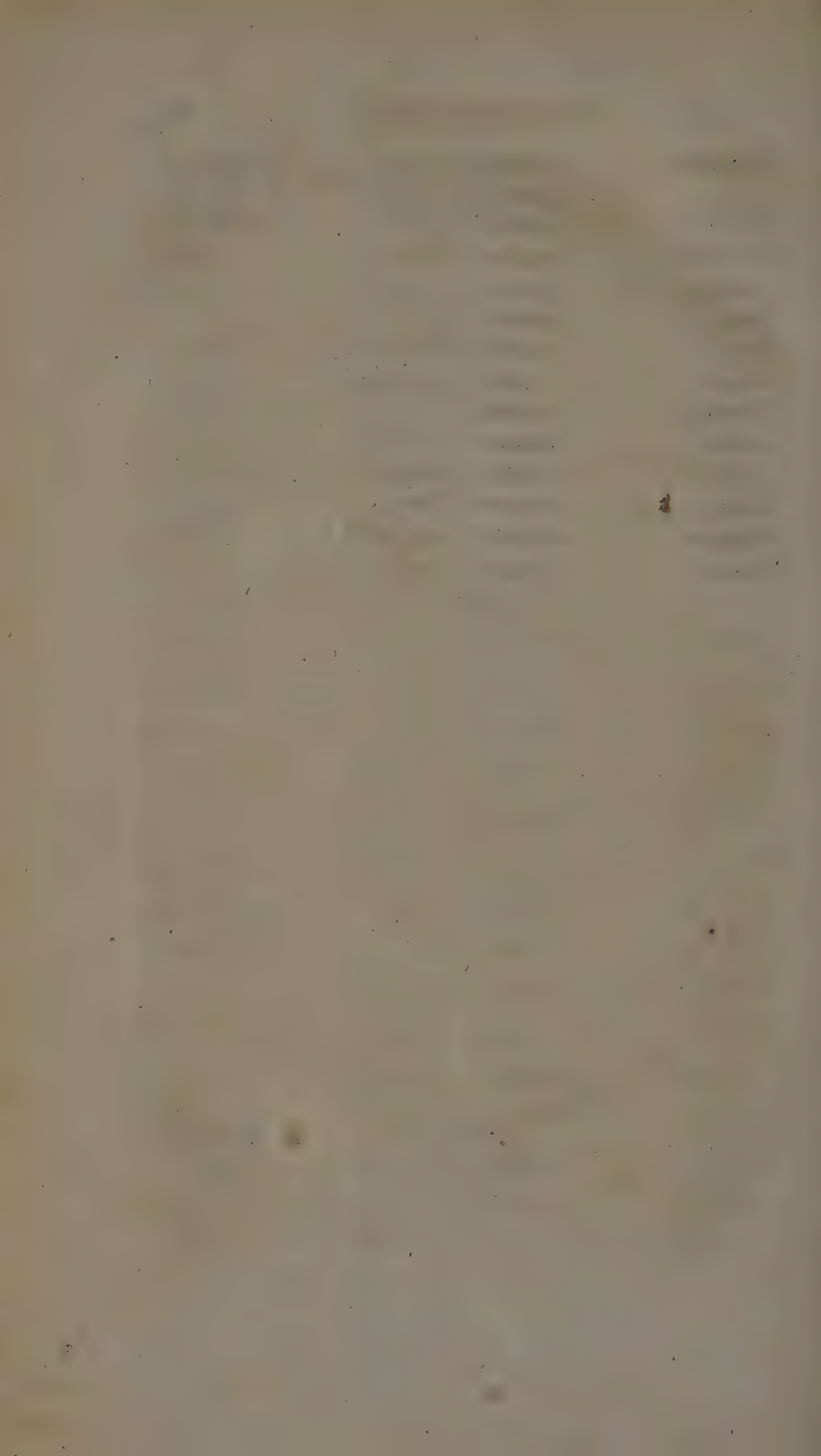
Number of Inhabitants in several of the great Cities and Towns of the World.

Amsterdam	210,000	Batavia	144,000
Astracan	70,000	Bergen	16,000
Avignon	10,000	Berlin	151,000
Bagdad	500,000	Berne	10,000
Barcelona	63,000	Birmingham	60,000
Bâle, Basle, or Basil	15,000	Bologna	70,000
Bastia (in Corfica)	5,000	Bonne	11,000
Bremen	40,000	Boston	25,000
Breslaw	60,000	Bordeaux	150,000
Brest	24,000	Bristol	60,000

Brunswick

Brunswick	28,000	Lisbon	200,000
Brussels	80,000	Leghorn	45,000
Buda	21,000	London	800,000
Cadiz	30,000	Loretto	4,000
Cairo	200,000	Lubec	30,000
Calcutta	600,000	Lucerne	6,394
Charleston	11,000	Lucca	3,000
Coblentz	12,000	Lyons	150,000
Constantinople	1,000,000	Madras	300,000
Copenhagen	90,000	Madrid	154,000
Cork	87,000	Manchester	65,000
Dantzic	48,000	Mentz	27,000
Dresden	50,000	Mexico	160,000
Dublin	150,000	Milan	152,000
Edinburgh	85,000	Modena	30,000
Embsen	7,500	Moscow	500,000
Florence	84,000	Manheim	22,000
Frankfort	43,000	Mantua	28,000
Ghent	60,000	Marfeilles	30,000
Genoa	110,000	Nantes	80,000
Geneva	27,000	Naples	440,000
Glasgow	30,000	Newcastle	40,000
Gottingen	7,600	Nice	12,000
Gotha	11,000	Norwich	40,000
Gottenburg	20,000	Ostend	16,000
Hamburg	120,000	Padua	38,000
Hanover	16,400	Palermo	120,000
Haerlem	20,000	Paris	600,000
The Hague	37,000	Pekin	2,000,000
Lausanne	80,000	Petersburg	220,000
Leyden	48,000	Philadelphia	35,000
Leipzig	32,000	Pisa	20,000
Liverpool	60,000	Potsdam	28,000
Liege	82,000	Ratisbon	22,000
Limeric	32,000	Rome	165,000
		Rotter-	

Rotterdam	50,000	Verona	57,000
Seville	120,000	Verfailles	40,000
Stockholm	80,000	Vienna	270,000
Shalmud	13,000	Ulm	15,000
Straßbourg	47,000	Utrecht	32,000
Stutgard	23,000	Weslar	4,600
Thorn	10,000	Wittenberg	7,000
Tiboli	18,000	Wurzburg	20,000
Tobolsk	15,000	York	12,700
Toledo	20,000	Yverdon	2,200
Trieste	18,000	Zittau	10,000
Turin	80,000	Zuric	12,000
Warsaw	120,000	Zanguebar	15,000
Venice	150,000		




A

T A B L E

OF THE

P R I N C I P A L M A T T E R S.

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- Page xlix. line 1, note, *for ea read ex*
 46. — 3, note, *for heavenly read heavy*
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 240. — 11. *after motion, add See Plate A, fig. 1.*

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- Page 28. line 10 *from the bottom, after Plate L add and F*
 31. — antepenult. note, *after month, add See Plate F, fig. 10.*
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